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COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE

Plenary Session, Paris, 14th-21st September, 1931

ENGLISH EDITION

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PREFACE TO THE ENGLISH EDITION.

This volume contains an unofficial translation of the official French text of the Proceedings of the COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE (C.C.I.) at its Plenary Session in Paris, 14th—21st September, 1931.

The English and French page numbers in the Contents (page iii) and in the Index (page 353) are printed in parallel columns so as to facilitate ready comparison between corresponding items in the English and French editions.

INTERNATIONAL STANDARD ELECTRIC CORPORATION.

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COMITE CONSULTATIF INTERNATIONAL DES COMMUNICATIONS TELEPHONIQUES A GRANDE DISTANCE.

PLENARY SESSION:
PARIS: 14th—21st SEPTEMBER, 1931.

I.—LIST OF DELEGATES.

A.—DELEGATES FROM TELEPHONE ADMINISTRATIONS AND OPERATING COMPANIES.

1.—Administrations and Companies belonging to the C.C.I.

SOUTH AFRICA
(*Union of South Africa*) ... Not represented.

ALBANIA ... ... Not represented.

GERMANY ... ... Professor Dr. Breisig, Deputy Ministerial Director (*Chief Delegate*).
Mr. Stegmann, Ministerial Councillor.
Mr. Höpfner, Ministerial Councillor.
Dr. Jäger, Ministerial Councillor.

ARGENTINE

Compania Union Telefonica del Rio de la Plata.

Compania Telefonica Argentina.

Compania Internacional de Radio.

Sociedad Anonima Radio Argentina.
Mr. E. M. Deloraine.

Compania Telefonica Telegrafico del Plata.
Dr. Lüschen.
Mr. B. Pohlmann.

Compania Internacional de Telefonos.
Dr. Max Langer.

Compania Transradio Internacional.
Mr. Bouthillon.

AUSTRIA ... ... Dr. Rudolf Oestreicher, Ministerial Councillor (*Chief Delegate*).
Mr. Hans Pfeuffer, Engineer, Councillor.

BELGIUM ... ... Mr. J. Van Ubbel, Chief Engineer, Director of Telephones (*Chief Delegate*).
Mr. M. Parfondry, Chief Engineer, Assistant Director.
Mr. H. Fossion, Assistant Director.
Mr. J. Haemers, Chief Engineer.

CHILI
Chile Telephone Company.
Mr. Lewis J. Proctor (*Chief Delegate*).
Mr. G. H. Nash.

CUBA
Cuban Telephone Company.
Mr. P. E. Erikson, Assistant Vice-President (*Chief Delegate*).
Mr. R. A. Mack, Assistant Vice-President.

DENMARK
(A) *Administration Delegates.*
Mr. M. J. Gredsted, Chief of International Telegraph and Telephone Service (*Chief Delegate*).
Mr. A. Gottlieb, Head of Technical Section of Telegraphs and Telephones.
Mr. N. Holmblad, Engineer, Technical Section of Telegraphs and Telephones.
Mr. Petersen, Engineer, Delegate from the Commission of State Supervision over Private Telephone Companies.

(B) *Delegate from Private Telephone Companies.*
Mr. L. Saltoft, Chief Engineer of Technical Section, Copenhagen Telephone Company

DANZIG (*Free City of*) ... Not represented.

SPAIN
(A) *Administration Delegates* (Ministry of Communications).
Mr. M. Hernandez Barroso, Director-General of Telegraphs and Telephones (*Chief Delegate*).
Mr. G. Hombre y Chalbaud, Head of International Traffic Section.
Mr. De la Penas, Telecommunication Engineer.
Mr. Hernandez Mendez, Secretary to the Director-General.

(B) *Delegates from Compania Telefonica Nacional de Espana.*
Mr. J. M. Clara Corellano, Telecommunication Engineer.
Mr. E. Del Riego Salazar, Operating Superintendent.

ESTHONIA ... ... Not represented.

UNITED STATES OF AMERICA
American Telephone and Telegraph Company.
Mr. H. E. Shreeve (*Chief Delegate*).
Mr. J. F. Bratney.

FINLAND ... ... Not represented.

FRANCE

(A) *Delegates from the French Administration of the P.T.T.*

Mr. Lange, Director of the Telephone Service (*Chief Delegate*).
Mr. Drouet, Inspector-General.
Mr. Rochas, Inspector-General.
Mr. Barillau, Inspector-General.
Mr. Aguillon, Chief Engineer.
Mr. Le Corbeiller, Chief Engineer.
Mr. Collet, Chief Engineer.
Mr. Chavasse, Engineer.
Mr. Belus, Engineer.
Mr. Cazals, Engineer.

(B) *Reception Committee.*

Mr. Crouzon, Chief of Reception Committee.
Mr. Decoust, Assistant Chief of Reception Committee.
Mr. Dartenuc, Chief Clerk.
Mr. Faure, Chief Clerk.
Mr. Leymarie, Comptroller.

GREAT BRITAIN ... ... Colonel Sir Thomas F. Purves, the Engineer-in-Chief, British Post Office (*Chief Delegate*).
Mr. B. L. Barnett, Principal, Secretary's Office, British Post Office.
Mr. H. G. Trayfoot, Inspector of Traffic, Secretary's Office, British Post Office.
Mr. W. G. Gilbert, Assistant Accountant-General, British Post Office.
Mr. S. T. Keyte, Accountant-General's Office, British Post Office.
Captain B. S. Cohen, Staff Engineer, Research Section, British Post Office.
Mr. C. Robinson, Staff Engineer, Engineer-in-Chief's Office, British Post Office.
Mr. A. J. Gill, Engineer, Engineer-in-Chief's Office, British Post Office.
Mr. C. A. Taylor, Engineer, Engineer-in-Chief's Office, British Post Office.
Lieutenant-Colonel Carter, Engineer, Engineer-in-Chief's Office, British Post Office.
Mr. B. J. Stevenson, Engineer, Engineer-in-Chief's Office, British Post Office.
Mr. G. Manning, Engineer, Engineer-in-Chief's Office, British Post Office.

HUNGARY ... ... Not represented.

DUTCH INDIES ... ... Baron Van Slingelandt, Chief Engineer of Posts, Telegraphs and Telephones.

ICELAND ... ... Mr. M. J. Gredsted.

ITALY

(A) *Administration Delegates.*

Mr. C. Albanese, Head of Department, Experimental Institute of Communications (*Chief Delegate*).
Mr. A. Baldini, Chief Technical Inspector, Experimental Institute of Communications.
Mr. E. Sacco, Inspector of the Telephone Service.

(B) *Delegates from Private Telephone Companies.*

Mr. L. Niccolai, Technical Expert of the S.I.R.T.I.
Mr. C. Della Rocca, Technical Expert of the S.I.R.T.I.

LETTONIA ... ... Not represented.

LITHUANIA ... ... Not represented.

LUXEMBOURG ... ... Dr. E. Jaaques, Director of Postal, Telegraph and Telephone Administration.

MEXICO ... ... Mr. L. Baciocchi, Mexican Consul at Havre (*Chief Delegate*).

(A) *Empresa de Telefonos Ericsson.*

Dr. M. Vos.
Mr. F. Markman, Engineer.
Mr. Blomberg, Engineer.

(B) *Mexican Telephone and Telegraph Company.*

Mr. E. A. Brofos, Vice-President.
Mr. S. M. Catterson, Assistant Vice-President.

MOZAMBIQUE ... ... Not represented.

NORWAY ... ... Mr. M. Wahl, Chief of Department, Telegraph Administration (*Chief Delegate*).
Mr. S. Rynning-Toennessen, Engineer, Telegraph Administration.

HOLLAND

(A) *Delegates from the Dutch Telephone Administration.*

Mr. H. J. Boetje, Engineer-in-Chief, Technical Director of Telegraphs and Telephones (*Chief Delegate*).
Mr. H. J. Claasen, Chief of the Telephone Division.
Mr. Tj. Nauta, Assistant Inspector of Posts, Telegraphs and Telephones.
Mr. J. Tj. Visser, Engineer, Technical Section of Telegraphs and Telephones.

(B) *Concessionary Municipal Telephone Networks.*

Mr. G. C. Snijders, Engineer, Director of Municipal Telephone Service, Amsterdam.

POLAND ... ... Not represented.

PORTUGAL ... ... Not represented.

RUMANIA

(A) *Societatea Anonima Romana de Telefoane.*

Mr. G. A. Ogilvie, Director-General (*Chief Delegate*).
Mr. J. J. Parsons, Traffic Director.
Mr. B. McCurdy, Engineer of Long Lines and Transmission.

RUMANIA (*contd.*). (B) *Rumanian Administration.*	Mr. Constantin Stefanesco, Inspector, Deputy-Director of Operating.
SWEDEN	Mr. A. Lignell, Director of Telephones, Stockholm (*Chief Delegate*). Mr. A. V. A. Holmgren, Head of Department, Telegraph Administration. Mr. G. Swedenborg, Engineer, Telegraph Administration. Mr. S. Nordström, Lines Engineer, Telegraph Administration.
SWITZERLAND	Mr. A. Muri, Head of Technical Division, Telegraph Administration (*Chief Delegate*). Mr. A. Moeckli, Head of Telephone Section, Telegraph Administration
CZECHO-SLOVAKIA	Mr. V. Kucera, Ministerial Councillor (*Chief Delegate*). Mr. J. Michalek, Engineer, Councillor.
UNION OF SOVIET SOCIALIST REPUBLICS.	Mme. Dobrouskina, Head of Electrical Section in the International Communications Department (*Chief Delegate*). Mr. Winetski, Engineer, Inspector of Long Distance Telephone Communications.
URUGUAY	Not represented.
YUGOSLAVIA	Mr. D. Katusic, Engineer, Director of Telephone and Telegraph Department, Ministry of Communications (*Chief Delegate*). Mr. D. Zlatanovic, Councillor, Higher Grade, Ministry of Communications.

2. **Representatives of Telephone Organisations, not belonging to the C.C.I. but invited to be present at the Plenary Session.**

Telephone Administration of Japan.

Mr. H. Igarashi, Engineer in the Ministry of Communications.
Mr. T. Naito, Interpreter.

3. **Representatives of the International Bureau of the Universal Telegraph Union.**

Mr. Boulanger, Vice-Director.
Dr. Jäger, Technical Adviser.
Mr. B. J. Stevenson, Technical Adviser.

B.—DELEGATES FROM ELECTRO-TECHNICAL ASSOCIATIONS.

1. **International Union of Railways.**

Mr. Müller, Assistant to the Chief Engineer of the Electrification Division of the Swiss Federal Railways.
Mr. Schulze, Technical Adviser to the German Railways.
Mr. Bachellery, Chief Engineer, Materials and Traction, Midi Railway Company.
Mr. Leboulleux, Chief Engineer, Permanent Way Department, Paris-Orleans Railway.
Mr. Micarelli, Chief Inspector, Italian State Railways.

2. **International Union of Producers and Distributors of Electric Energy.**

Mr. J. Garczynski, Assistant Chief of the Compagnie Générale du Gaz pour la France et l'Etranger.

Mr. Lohr, Director of the Electrification Company of the Province of Gueldre.

Mr. Bourquin, Engineer, Swiss Association of Electricians and Swiss Central Union of Electricity.

3. **International Union of Tramways, Local Railways and Public Motor Transport.**

Mr. de Backer, General Secretary to the International Union of Tramways.

Mr. J. Knaff, Engineer, Brussels Tramway Company.

Mr. J. Peridier, Director of Research and Control of the Communal Transport Company in the Paris area.

Mr. R. Podoski, Engineer, Professor of the Warsaw Polytechnic.

4. **International Broadcasting Union.**

Mr. Braillard, President of the Technical Commission and Director of the International Broadcasting Union.

Mr. Hayes, Engineer, British Broadcasting Company.

Mr. Schäffer, Engineer, Reichs-Rundfunk Co.

5. **International Union of the Gas Industry.**

Mr. Mougin, General Secretary.

Mr. Baril.

II.—MINUTES OF THE OPENING MEETING.

The meeting opened at 10.00 a.m.

Mr. Lange: Ladies and Gentlemen, M. Charles Guernier, Minister of Posts, Telegraphs and Telephones, has conferred on me the honour of extending to you a cordial welcome. He notes with pleasure the venue of the VIIIth Plenary Meeting of the C.C.I. at Paris. He expresses the hope that your labours will be successful and will be very glad to make your acquaintance next Thursday.

More than a year has elapsed since we last met and our thoughts first turn to those of our colleagues, who then in full vigour of life, are now no longer with us.

Since I have the privilege of being the first speaker, allow me to pay a tribute to the memory of two of our dear departed: Mr. Wiehl and Mr. Rebillat.

Mr. Wiehl has been a member of the German delegation since the formation of the C.C.I. His courteous manner and high qualifications have earned for him a prominent position among us. His contributions to the work of the VIth and VIIth Commissions were always of a high order and he died greatly esteemed by us all. We shall always cherish the memory of Mr. Wiehl.

Mr. Rebillat was for several years the Secretary of the VIth and VIIth Commissions of Rapporteurs, which have thus suffered another loss. His zeal and devotion endeared him to all. I feel the loss particularly, as to me and several members of the French delegation he was daily a most valued collaborator. Those who knew him will not forget this fine man.

The past year has seen a substantial increase in the number of countries which have joined the C.C.I. I have pleasure in announcing to you the names of the new members:—

The Telephone Administration of the Dutch Indies.

The Telephone Administration of the Union of South Africa.

Chili, represented by Chile Telephone Company.

Uruguay, represented by Compania Telefonica de Montevideo and by Sociedad Cooperativa Telefonica Nacional.

Finally, the Societatea Anonima Romana de Telefoane, concessionaries of public telephones in Rumania, will from now on participate in the work of the C.C.I. with the Régie Autonome des Postes, Télégraphes et Téléphones of Rumania.

I cannot help remarking that these five countries are located in four corners of the earth. What a token of the universal character of the C.C.I. I am sure that I speak for you all in extending a warm welcome to our new and distinguished colleagues.

I also extend a hearty welcome to Messrs. Boulanger, Jäger and Stevenson, who represent the Bureau of the International Telegraph Union. In anticipation I also welcome the representatives of the International Railway Union, the International Union of Producers and Distributors of Electrical Energy, the International Conference on High Tension Electrical Networks, the International Union of Tramways, Local Railways and Public Motor Transport, and the International Union of the Gas Industry. These eminent engineers will join us on Wednesday, 16th September.

We shall also have the pleasure of seeing among us on Thursday, 17th September, representatives of the International Broadcasting Union.

Finally, I greet Messrs. Igarachi and Naito, who, by invitation, represent the Telephone Administration of Japan as observers.

And now it only remains for me to express the hope that you will spend a pleasant week in Paris. The French Administration will do its best to help you to do so. It will only be necessary for us to try and imitate the German and Belgian Administrations, who have left on our minds unforgettable memories of Berlin and Brussels.

Ladies and Gentlemen, I now invite you to nominate the President of the VIIIth Plenary Meeting.

Colonel Sir Thomas Purves: Gentlemen, we are meeting once more in Paris and I think it is fitting that the Director of the Telephone Service in France should be elected as President. In this capacity Mr. Lange has succeeded Mr. Milon, our usual President, whom we hold in very pleasant and affectionate memory.

I think you will all join me in congratulating Mr. Lange on the official promotion he has received since our last meeting.

We have full confidence in Mr. Lange and I propose to you that he be elected President of the Plenary Meeting of 1931. (Applause.)

Mr. Lange: I thank Colonel Sir Thomas Purves most heartily for his kind words and am deeply touched by his proposal, which is in line with the traditions of the C.C.I. Although unworthy of the honour bestowed on me, I bow to the rules of custom which may sometimes override reason.

I must not forget to join Colonel Sir Thomas Purves in remembering Mr. Milon, my distinguished predecessor and our beloved colleague, who in the past led our discussions with an authority which I envy him. All I can promise is to make every effort to take him and other eminent past-Presidents as examples.

It is now my traditional duty to name three Vice-Presidents to direct the working Committees of this meeting.

I am sure that I am acting in accordance with your wishes in nominating Colonel Sir Thomas Purves for the Transmission Meetings, Dr. Breisig for the Protection Meetings, and Mr. Muri for the Traffic, Operating and Tariffs Meetings. (Applause.)

Colonel Sir Thomas Purves: I am greatly honoured by your choice and gladly accept.

Dr. Breisig: I thank you most cordially and likewise accept.

Mr. Muri: I thank you for the honour you have shown me which I feel very deeply, and I shall do my best to carry out my duties.

Mr. Lange: I note the unanimous approval of the meeting and I will now call on our able General Secretary, who will give you some information regarding the dossiers which have been referred to the Chief Delegates and make some suggestions to you with regard to the organisation of the Secretarial Bureau during the Plenary Meeting.

Mr. Valensi: Ladies and Gentlemen, I should first like to say how glad I am to see my good colleagues of former Plenary Meetings once again and to express my pleasure at making the acquaintance of the new delegates.

Allow me to read a letter addressed to me by Professor di Pirro :—

" An unfortunate accident (a strained tendon), which prevents me from travelling with ease, has made it impossible for me to come to Paris. I very much regret this mishap which prohibits my taking part in the meetings of the Assembly, more especially as the questions to be dealt with are very interesting.

" Ad impossibilia nemo tenetur, and I must resign myself to the disappointment of not being able to see my colleagues.

" I send my best wishes for the complete success of your labours.

" With very kindest regards, dear Mr. Valensi.

" Yours very sincerely,

" Di Pirro."

I am sure that I shall be expressing the general sentiment in sending Professor di Pirro a telegram telling him how sincerely we regret his absence, and wishing him a speedy recovery and thanking him for his good wishes for our success. (Applause.)

The Chief Delegates will have found before them a dossier containing several documents in regard to which I should like to give some explanations. Each dossier contains a note on which the Chief Delegates are asked to inscribe the names and titles of the members of their respective delegations and thus enabling us to compile a definite list of delegates to the VIIIth Plenary Meeting of the C.C.I. for the Closing Session, the list sent to you this morning by the Reception Committee being of a purely provisional nature.

The next item in the dossier is a programme for the work of this meeting, which is submitted for the approval of the Plenary Meeting. The programme, which has already been sent to the various Administrations and Companies of the C.C.I. in my letter of 16th July, 1931, outlines three groups of meetings in accordance with past practice, namely :—

Transmission meetings, 10 a.m. to 12 noon.
Meetings for traffic, operating and tariffs, 2 p.m. to 4 p.m.
Meetings on protection, 4.30 p.m. to 6 p.m.

The half hour, 4 p.m. to 4.30 p.m., constitutes an interval for tea.

Representatives of the International Railway Union, the International Union of Producers and Distributors of Electrical Energy and the International Conference on High Tension Electrical Networks have been invited to attend the meeting on protection against high tension interference on Thursday, 17th September : it appears that one Plenary Meeting will be sufficient to deal with the questions concerning collaboration with members of these International Unions.

On the other hand, representatives of the International Railway Union, the International Union of Producers and Distributors of Electrical Energy, the International Union of Tramways, Local Railways and Public Motor Transport and the International Union of the Gas Industry have been invited to attend a meeting on protection against corrosion from electrolysis on Wednesday, 16th September : these International Unions have already received the minutes of the meeting of the 2nd Commission of Rapporteurs in Berne, May, 1931, which examined these questions of corrosion : it is, however, possible that one Plenary Meeting may not be sufficient to reach an agreement between the International Unions and the C.C.I. on this subject. For this reason the first meeting has been set for Wednesday, 16th September ; it will be continued, if necessary, during the course of the second meeting of the

Plenary Session for protection against corrosion, which can take place on Friday, 18th September, at 4.30 p.m., instead of the meeting of the Chief Delegates scheduled for that time. In that event, the meeting of the Chief Delegates will be postponed until Monday, the 21st, from 10 a.m. to 12 noon, and the Closing Meeting deferred until the afternoon of Monday, the 21st September.

It is, however, hoped that one Plenary Meeting will be sufficient for the meeting dealing with corrosion so that, subject to the approval of the meeting, it may be possible for the present to confine the programme to the limits already set.

Mr. Lange: Has anyone any observations to make concerning the subject of the working programme of the Plenary Meeting? As such is not the case the programme is considered as adopted.

Mr. Valensi: The third document in the dossier, now in the hands of the Chief Delegates, is a list of the meetings of the Commissions during the Plenary Meeting and of those which are additional thereto.

The VIth and VIIth Commissions of Rapporteurs have already met on 11th and 12th September, 1931, and the minutes of these meetings are attached to the supplementary list of documents prepared for the Plenary Meeting, contained in the dossier.

This afternoon (Monday, 14th September) a visit will be made to the Laboratory of the European Master Reference System ("SFERT"). The "SFERT" Laboratory will, this afternoon, carry out tests applying to the maximum limits of reference equivalents for international telephone communications, recommended by the 3rd C.R. for adoption of the Plenary Meeting, as also tests on objective measurements of noise. In order to facilitate the discussion on these questions during the Plenary Meeting it is very desirable that the delegates should themselves observe the quality of transmission which corresponds to the values of the reference equivalents proposed as maxima limits, as well as noting the performance of the first models of apparatus, intended for the objective measurement of noise, which have been developed in Germany and the United States of America. The visitors to the Laboratory will be divided into two groups, one leaving the Sorbonne at 2.30 p.m. and returning at 4 p.m., the other leaving the Sorbonne at 4.30 p.m. and returning at 6 p.m. Delegates wishing to take part in this visit are asked to inform the Reception Committee at once, using the forms provided for that purpose.

Meetings of the 2nd, 3rd and 4th C.R. are scheduled for to-morrow, 15th September. The 2nd C.R. will meet in Room No. 2 in the morning, whilst the 3rd and 4th C.R. will meet in the afternoon in Room No. 1.

Administrations and Operating Companies, in a letter dated 24th July, 1931, have been asked to attend a meeting of the "Commission on the revision of emergency routes in the European telephone service" which is to be held on the occasion of the Plenary Meeting in Paris, 1931, but not as part of the Plenary Meeting. This Committee will meet to-morrow, Tuesday, in Room No. 1. The Chief Delegates are asked to give the Secretariat the names of the members of their delegation who will attend this meeting.

Furthermore, the Telephone Administrations of Germany, Austria, Belgium, Denmark, France, Great Britain, Hungary, Italy, Norway, Holland, Sweden, Switzerland and Czecho-Slovakia, whose representatives prepared the first "Programme of periodic maintenance of the main European international telephone circuits" at the last Plenary Meeting of the C.C.I. held in Brussels in June, 1930, have been asked by letter dated 24th July, 1931, to attend a meeting of the "Commission for the revision of the first programme of periodic maintenance." This latter meeting will be held on the occasion

of the present Plenary Meeting, but will not form part thereof. The Chief Delegates of the thirteen countries mentioned are asked to give the Secretariat the names of the members of their delegation who will attend this meeting which will take place on Wednesday, 16th September, 1931, at 4.30 p.m., in Room No. 1.

Perhaps the Plenary Meeting may wish to extend an invitation to all European Administrations and Operating Companies to send representatives to the Commission on periodic maintenance.

Mr. Lange: Apart from the thirteen countries mentioned by Mr. Valensi, are any other countries desirous of being represented on the Commission on periodic maintenance? As such is not the case, the Commission will be confined to the thirteen countries.

Mr. Valensi: The fifth document in the Chief Delegates' dossier is a list of questions, submitted for the approval of the VIIIth Plenary Meeting of the C.C.I. This list has already been sent to the Administrations and Operating Companies by letter dated 16th July, 1931. The questions to be dealt with are classified according to the seven C.Rs. appointed by the Plenary Meeting of Brussels, June, 1930. The documents which will form the basis of discussion are given on this list and were sent to the Administrations and Operating Companies in June and July, 1931.

The last document in the Chief Delegates' dossier is a supplementary collection of papers prepared for the VIIIth Plenary Meeting. The first is the Rapport de Gestion for 1931, of which the Appendices I, II and III (pages 9-20) form the basis of the only organisation question on the programme of this Plenary Meeting, namely, the classification of membership fees, payable by the various countries belonging to the C.C.I.

The second is Report on the Budget (1931), which will be examined by the meeting of the Chief Delegates. The auditors of the C.C.I. accounts have already approved the account for 1930 as well as the proposed Budget for 1932 which is incorporated in the report.

The third is a paper, entitled "C.C.I. 1st C.R.—Document No. 26, which replaces Document No. 25 of the 1st C.R., distributed in July, 1931. Document No. 26 should form the basis for the discussions on questions pertaining to the protection of telephone lines against disturbances from electric power installations. It is, in fact, the final report of the 1st C.R. and is more complete than Document No. 25, which is the preliminary minutes of the meeting in Prague of the 1st C.R.

The supplement to "C.C.I. 1931—2nd C.R.—Document No. 7," mentioned in the list of preparatory documents, will be distributed to the Chief Delegates this afternoon. This supplement contains a proposed new recommendation concerning the protection of cable sheath against electrolytic corrosion. The 2nd C.R. will formulate the final text during their meeting this morning.

The fifth document in the supplementary list (C.C.I. 1931—3rd C.R.—Document No. 34) is a technical report from the "SFERT" Laboratory, detailing the tests to be made this afternoon in the laboratory. Delegates who intend visiting the laboratory may be interested in a preliminary perusal of this report.

The next two documents (C.C.I. 1931—3rd C.R.—Documents No. 35 and 36) will be discussed this afternoon by the 3rd and 4th C.Rs., who will also consider Document No. 37, which will form the agenda for the meeting of the 3rd and 4th C.R. to-morrow afternoon. Document No. 37 will be distributed to the Chief Delegates the day after to-morrow.

The last document, attached to the supplementary list (Document C.C.I. 1931—7th C.R.—Document No. 12) is the minutes of the meetings of the 6th and 7th C.R., which took place on 11th and

12th September in Paris. Part of Document No. 12 will form the basis of a discussion on Question No. 12 (on the programme of this Plenary Meeting), concerning international telephone rates.

It now only remains for me, in line with the President's remarks, to propose to the meeting the organisation of the Secretarial Bureau for this Plenary Meeting. I propose the following division of duties :—

For questions on organisation and protection : Mr. Ollier.

For transmission and maintenance questions : Messrs. Bigorgne and Labrousse.

For traffic, operating and rate questions : Mr. Legros.

Mr. Bigorne will also act as Secretary to the Commission on the revision of periodic maintenance and Mr. Legros as Secretary to the Commission on the revision of the list of emergency routes.

Mr. Lange : Is this proposal approved ? I note that it has your approval. I will now call on Mr. Crouzon, Chairman of the Reception Committee, who will give you some information and explanations.

Mr. Crouzon : The delegates will have found in their envelopes a note from the Reception Committee, as well as an identity card and a badge.

As indicated on the identity card, on which your signature should be written, the delegates may frank their letters by handing them in at the office located at the extreme end of the peristyle. They may also send telegrams to their families, their Administrations and Operating Companies from that office free of charge. They will also have the privilege of free telephone calls from the telephone booths installed in this building or from their hotels. For accounting reasons telegrams and telephone calls should be designated by the word " Conference."

Delegates are asked to let us know, as soon as possible, their Paris address in order that we may, first of all, notify the hotels regarding the telephone facilities afforded to delegates and also in order that we may forward telegrams or letters arriving at the Sorbonne outside meeting hours. Such messages will normally be deposited in the letter box assigned in alphabetical order to each delegate.

The note from the Reception Committee now in your possession contains an invitation to a dinner given by the Minister of Posts, Telegraphs and Telephones, on Thursday, 17th September, at 7.45 p.m., at the Musée Permanent des Colonies in the International Colonial Exhibition. After the dinner, between 10 p.m. and 11 p.m. there will be an entertainment of native dances and this will be followed by a ball, commencing at 11 p.m. The invitation is extended to the ladies accompanying the delegates, and the Reception Committee will be obliged if prompt notice can be given of the number of people who will be present in order that arrangements may be made accordingly.

On Saturday, 19th September, there will be an excursion to the Castle of Loire, to which ladies are also invited. The trip will be by special train from Paris to Blois, by motor chars-a-bancs from Blois to Tours with visits to the Castles of Chambord, Blois, Amboise and Chenonceaux, whence a special train will bring the visitors back to Paris. Lunch will be served in the historic Salle des Etats Généraux in the Castle of Blois, and dinner will be served at the Grand Hotel, Tours. A brief notice in the envelope gives some further particulars and a time table of the excursion.

You will also find in the envelope a special admission card to the Colonial Exhibition, valid during the last fortnight of September. Please fill in your name on this card and append your signature. A similar card will be provided, on request, for ladies accompanying the delegates.

The Reception Committee thanks you in advance for your assistance in their endeavours, which will be directed towards making your sojourn in Paris as pleasant as possible. The Committee is at your entire disposal for any information you may need.

Mr. Lange: The customary photograph will be taken in the great amphitheatre of the Sorbonne at 11 o'clock and as the weather is favourable another photograph will be taken in the courtyard of the Sorbonne. There are 20 minutes available before 11 o'clock and I would ask delegates to use that interval to fill in the forms and notes which Messrs. Valensi and Crouzon have distributed to them.

The meeting closed at 10.40 a.m.

III.—QUESTIONS OF GENERAL ORGANISATION.

DISTRIBUTION OF THE EXPENSES INCURRED IN THE OPERATIONS OF THE INTERNATIONAL CONSULTATIVE COMMITTEE.*

Each member country of the C.C.I. has the right to choose between (*a*) classification of expense in accordance with the scale adopted by the International Telegraph Union † and comprising six classes and (*b*) a table of classification based on the population of each country and likewise divided into six classes, as follows :—

First Class :	Population exceeding 35 millions of inhabitants.
Second Class :	Population between 35 and 20 millions of inhabitants.
Third Class :	Population between 20 and 8 millions of inhabitants.
Fourth Class :	Population between 8 and 3 millions of inhabitants.
Fifth Class :	Population between 3 and 1 million of inhabitants.
Sixth Class :	Population less than 1 million of inhabitants.

The nations in the First Class shall each pay 25 units; those of the Second Class 20 units; those of the Third Class 15 units; those of the Fourth Class 10 units; those of the Fifth Class 5 units; and those of the Sixth Class 3 units.

The contributing shares will be paid fully in advance on the 1st of January each year, by cheque or warrant (virement de compte) in gold francs. (For a definition of the gold franc see the International Regulations, Brussels, 1928, Art. 24.)

In case several Operating Companies from the same country are represented on the C.C.I., they are invited at the time of joining to agree among themselves how the common fee should be divided. If no agreement is reached, the charge shall be equally divided among the Companies.

* This text replaces the corresponding paragraph in the *Livre Jaune* (pp. 26-27), Brussels, 1930 (English text, p. 13).
† Column headed " Telegraphy," or in default thereof, the column headed " Radio Telegraphy."

IV.—QUESTIONS OF TRANSMISSION, MAINTENANCE AND SUPERVISION OF LINES AND INSTALLATIONS.

A. Advice of the International Consultative Committee.

(*a*) General.

1. Transmission Standards and Definitions.
2. Recommendations of Principle.

(*b*) General Rules concerning the Composition of Transmission Systems.

1. Ordinary Telephony.
2. Carrier Current Telephony.
3. Radio-Broadcast Transmission.
4. Picture Transmission.

(*c*) Apparatus.

1. Subscribers' Instruments.
2. Local Exchanges.
3. Toll Exchanges.
4. Telephone Repeater Stations.

(*d*) Lines.

1. Overhead Lines.
2. Cables.
   - (α) General.
   - (β) Aerial Cables.
   - (γ) Underground Cables.
   - (δ) Submarine Cables.
3. Mixed Lines.

(*e*) Maintenance and Supervision of Lines and Installations.

(*f*) Co-existence of Telephone and Telegraph Circuits in the same Cable.

(*g*) Co-ordination of Radio Telephony and Telephone Systems.

B. Essential Clauses for Typical Specifications.

C. Bibliography.

A.—ADVICE OF THE INTERNATIONAL CONSULTATIVE COMMITTEE ON LONG DISTANCE TELEPHONE COMMUNICATIONS.

(A.a.)—GENERAL.

(A.a.1)—Transmission Standards and Definitions.

Transmission Unit.

No changes or modifications have been made in the text on pp. 41 and 42 of the " Livre Jaune " (English text, p. 21).

Method of expressing Frequency.

No changes or modifications have been made in the text of the " Livre Jaune," p. 42 (English text, p. 22).

Definition of some Expressions used in Questions of Telephone Transmission.*

The International Consultative Committee proposes unanimously the following definitions :—

(*a*) **Népers and Decibels.**

In telephone transmission the relation between two magnitudes having the same physical dimensions is expressed by the logarithm of the ratio. For instance, one speaks of the logarithm of the ratio of two powers, real or imaginary, of two voltages, of two currents, of two acoustic pressures, etc.

In practice either the Napierian or decimal system of logarithms is used.

If two powers P_1 and P_2 are concerned, the number of units is :—

In the Napierian system.	In the decimal system.
$\frac{1}{2} \log_e \frac{P_1}{P_2}$;	$10 \log_{10} \frac{P_1}{P_2}$.

If two voltages V_1 and V_2 or two currents I_1 and I_2 are concerned, the number of units is :—

In the Napierian system.	In the decimal system.
$\log_e \frac{V_1}{V_2}$ or $\log_e \frac{I_1}{I_2}$;	$20 \log_{10} \frac{V_1}{V_2}$ or $20 \log_{10} \frac{I_1}{I_2}$.

It is usual to call the results obtained with the Napierian logarithms " népers " and those obtained with the decimal logarithms " decibels."

These units give, therefore, an indication of the system of logarithms used.

In the official documents of the C.C.I. units of transmission will be expressed in both népers and decibels; as for example :—

A transmission equivalent of 3 népers or 26 decibels written in full thus " népers " or " decibels."

In documents other than official C.C.I. literature, the symbols " n " for népers, " db " for decibels, and " dn " for decinéper, are sometimes used.

* This text replaces pp. 42-47 of the *Livre Jaune* (English Edition, pp. 22-25).

In special cases hereafter the term "*determined*" means that the calculation must be carried out by means of the formulæ given above.

(*b*) **Special Definitions.**

1. The **acousto-electric index (efficacité absolue, akustoelektrisches Verhältnis)** of any transmitting system at any frequency is the ratio of the voltage measured at the output of the system to the acoustic pressure measured on the diaphragm of the transmitter at the frequency considered; the output of the system is assumed to be closed with an impedance of 600 ohms with zero angle; this ratio is expressed in volts per bar.

2. The **electro-acoustic index (efficacité absolue, elektroakustisches Verhältnis)** of any receiving system at any frequency is the ratio of the acoustic pressure to half the electro-motive force of the generator, having an internal impedance of 600 ohms with zero angle, connected to the input terminals of the system; this ratio is expressed in bars per volt.

3. The **reference equivalent (équivalent de référence, Bezugsdämpfung)** of a **transmission system (système de transmission, Übertragungsystem)** is the reading given by the Master Telephone Transmission Reference System, without distorting networks, when this Master Reference System is adjusted so as to give the same volume of sound at the receiver terminals as the system under consideration—the acoustic power supplied being identical in both instances.

The sign of the reference equivalent is so chosen that a positive sign indicates that the system is less efficient than the Master Reference System with zero line attenuation between its transmitting and receiving systems.

4. The **reference equivalent** of a principal part of a transmission system

(système émetteur—transmitting system—Sender
ligne —line —Leitung
système récepteur— receiving system —Empfänger)

is the reading indicated by the corresponding part of the Master Reference System (without distorting networks) when adjusted to give the same volume of sound at the receiving end before and after the substitution of the part under test for the corresponding part of the Master Reference System, the acoustic power supplied being identical in both instances.

The sign of the reference equivalent is so chosen that a positive sign indicates that the part under test is less efficient than the corresponding part of the Master Reference System.

Note.—If it is desired to calculate the reference equivalent of a given transmission system from measurements of the component parts of such a system (transmitting system, line, receiving system), it is necessary to apply certain correcting factors, in order to account for the combined effects of the distortion characteristics of the different parts of the system as well as the effects of differences of impedance.

5. The **relative equivalent (équivalent relatif, relative Dämpfung)** of a system A compared to another system B, or of a part of system A compared to the corresponding part of another system B, is the difference: $a-b$, where a represents the reference equivalent of A, and b the reference equivalent of B.

Note.—When the "SFERT" laboratory, under certain circumstances, has to measure, by the method of substitutions, the reference equivalent or the electro-acoustic index of a system or a component part of a system, having an impedance differing from the impedance of the corresponding elements of the "SFERT," it is useful in making such comparisons to have available formulæ containing only the magnitudes relating to the transmitting or receiving systems under consideration.

In order to make the test results comparable it is agreed to utilise the magnitudes

$$u_m/\sqrt{R} \text{ and } u_t/\sqrt{Z},$$

where R is the impedance of the transmitting system, Z the impedance of the receiving system, u_m and u_t are the acousto-electric and the electro-acoustic indices of the transmitting and receiving systems respectively. The relative equivalent, expressed in népers, may be written in the following forms :—

$$(a) \ldots\ldots \log_e u'_m/u''_m\sqrt{R''/R'},$$

where R′ and u'_m apply to the first transmitting system

R″ and u''_m apply to the second transmitting system

for the case, in which the two transmitting systems emit the maximum apparent power.

$$(b) \ldots\ldots \log_e u_m/u_{m_0}\sqrt{600/R}$$

when the comparison is with the transmitting system of a reference system.

Analogous formulæ apply to the relative equivalent of the receiving systems.

6. The **relative transmission level (niveau relatif, relative Übertragungspegel)** of the power, of the current, or of the voltage at a point in a system is *determined* by the ratio of the magnitude considered (power, voltage or current) to the value of the corresponding quantity at a point of the system which is chosen as the point of reference.

The **absolute level (le niveau absolu, absolute Pegel)** of the power of the voltage or of the current is *determined* by the ratio of the magnitude considered at that point to :—

1 mW for power.
775 mV for voltage.
1.29 mA for current.

At any point in a circuit three things are to be distinguished : the relative level, the absolute level and the speech volume (speech power).

The conception of absolute and relative levels refers to the transmission of testing current, whereas that of volume refers to transmission of speech, as in a telephone conversation.

The transmission measuring apparatus used at present is calibrated in terms of absolute level.

The **hypsogram** is a diagram of relative transmission levels (Diagramme des niveaux relatifs—Übertragungspegellinie) of the power, voltage or current at different points in the system.

If it is desired to avoid corrections in determining the transmission levels, it is necessary during the test to adjust the generator, which feeds the circuit in such a manner that the magnitude considered (power, voltage or current) is equal to 1 mW for the power, 775 mV for the voltage and 1.29 mA for the current at the point chosen as the point of reference.

7. The **crosstalk (diaphonie, Nebensprechdämpfung)** between two systems—disturbing and disturbed—is *determined* by the ratio between the apparent powers obtained at given points on the disturbing and disturbed systems under specified terminal conditions (for example, by means of image impedances).

8. **Image attenuation (affaiblissement image, Vierpoldämpfung).** This expression applies to a quadripole electric system terminated by its image impedances ; it is *determined* by the ratios of the apparent powers at the ends of the system so terminated.

In the special case in which a homogeneous line, or more generally a line made of identical symmetrical units, such as a coil-loaded line terminated at mid-section, is terminated by impedances equal to its characteristic impedance and is traversed by a sinusoidal current which has reached its steady state, we have—

$$\log_e \left|\frac{V_2}{V_1}\right| = \log_e \left|\frac{I_2}{I_1}\right| = \tfrac{1}{2} \log_e \left|\frac{P_2}{P_1}\right|$$

where V_1, I_1 and P_1 represent the voltage, current and power respectively at one point, and V_2, I_2 and P_2 the voltage, current and power respectively at another point.

These expressions represent the attenuation (affaiblissement, Dämpfung) of the line in question between the given points.

The **attenuation constant (constante d'affaiblissement** or **affaiblissement linéique, Dämpfungskonstante)** of a homogeneous line is the quotient of the image attenuation between its terminals divided by its length.

It follows that the attenuation constant of a line made up of a number of similar units, such as a coil-loaded line terminated at mid-section, is the quotient of the image attenuation between its terminals divided by its length.

9. **Effective attenuation (affaiblissement effectif, Betriebsdämpfung).**

The effective attenuation of a part of a system terminated by impedances Z_1 and Z_2 is *determined* by the ratio between the apparent power delivered by a generator of impedance Z_1 to a receiver of impedance Z_1 and the apparent power delivered by the same generator through the part of the system in question to a receiver of impedance Z_2.

If this ratio is negative it is called the **effective amplification (amplification effective, Betriebsverstärkung).**

In the particular case in which $Z_1 = Z_2 = 600$ ohms with zero angle, the effective attenuation is represented by the same number of units as the reference equivalent, as defined above.

10. The **loss,** or **gain,** introduced by a part of a system between an input impedance Z_1 and an output impedance Z_2, is *determined* by the ratio of the apparent powers received in the impedance Z_2, before and after the insertion of the part of the system between Z_1 and Z_2.

If the apparent power received by the impedance Z_2 is greater than before the insertion of the part of the system, the result is a gain, and, conversely, a loss.

If $Z_1 = Z_2 = 600$ ohms with zero angle, the loss or gain thus defined is expressed by the same magnitude as the reference equivalent of the part of the system considered.

11. **Damping (amortissement, zeitliche Dämpfung).** This is a general term, indicating the decrease in a certain quantity (current, voltage, power, pressure, etc.) as a function of time.

12. **Articulation and Intelligibility.** A logatome is an elementary vocal emission of connected speech, *i.e.*, the shortest possible element of speech. (Etymology:—λογοσ, element of speech; ατομοσ, indivisible.)

It has been agreed to use in articulation tests only logatomes made up of: a consonance (single consonant or group of consonants), one intermediary vowel and a closing consonance.

From an acoustical standpoint a logatome contains: the formants (essential frequency components of a complex sound) of an initial consonant sound, the formants of an intermediary vowel sound and the formants of a closing consonant sound.

The logatome articulation (netteté pour les logatomes, Silbenverständlichkeit) is characterised by the percentage of logatomes, contained in standard lists, correctly received with respect to the total number of logatomes transmitted.

The sound articulation (netteté pour les sons, Lautverständlichkeit) is derived from a measurement of logatome articulation by counting the percentage of vowel or consonant sounds correctly understood with respect to the total number of vowel and consonant sounds contained in the logatomes transmitted.

The C.C.I. has prepared a list of logatomes for articulation tests, taking as a basis the principal sounds of the European languages most extensively used, and grouping these sounds in such a manner that the logatomes built up can easily be pronounced in Esperanto. Experience has shown that it is better to use Esperanto characters in preference to the method of indicating the pronunciation of the logatomes in terms of the mother tongue of each operator.

The "word intelligibility" (netteté pour les mots, Wortverständlichkeit) is characterised by the percentage of words forming standard lists correctly received with respect to the total number of words transmitted.

The "phrase intelligibility" (netteté pour les phrases, Satzverständlichkeit) is characterised by the percentage of sentences of any text correctly received with respect to the total number of sentences transmitted.

The "intelligibility" (intelligibilité, Sinnverständlichkeit) is characterised by the percentage of words correctly received with respect to the total number of words transmitted in a continuous conversation.

TELEPHONE TRANSMISSION REFERENCE SYSTEMS.*

Object of Telephone Transmission Reference Systems.

The International Consultative Committee—
Unanimously advises:—

That a Master Telephone Transmission Reference System, capable of being rigorously defined and of being reproduced exactly, is essential for procuring a constant base for transmission measurements and for the co-ordination of the transmission data relating to the systems of telephony utilised in all countries.

In addition, other systems must be adopted to determine:—

1. Transmission equivalents.
2. Relative equivalents.
3. Transmission losses and gains.
4. The articulation of a system or of one of its parts.
5. The co-efficient of experimental practice of a team engaged in articulation measurements.

* This text replaces pp. 47-59 of the *Livre Jaune* (English Edition, pp. 25-35).

THE SETTING UP OF TELEPHONE TRANSMISSION REFERENCE SYSTEMS.

The International Consultative Committee recommends that the number of types of Telephone Transmission Reference Systems should be reduced to three, as follows :—

I. Master telephone transmission reference systems.
Système Fondamental de Référence pour la transmission téléphonique.
Ureichkreis für die Fernsprechübertragung.
(The European Master System is referred to, briefly, as " SFERT.")

II. Telephone transmission reference systems.
Systèmes de référence pour la transmission téléphonique.
Haupteichkreise.

III. Working standards.
Etalons de travail.
Arbeitseichkreise.

CONDITIONS WHICH SHOULD BE FULFILLED BY THE TELEPHONE TRANSMISSION REFERENCE SYSTEMS.

I.—THE MASTER TELEPHONE TRANSMISSION REFERENCE SYSTEM.

(Le Système Fondamental de Référence pour la transmission téléphonique, Ureichkreis für die Fernsprechübertragung).

This system is rigorously defined in the documents kept by the Secretary-General of the C.C.I. and at the Master Telephone Transmission Reference System Laboratory (Conservatoire des Arts et Métiers, 292, Rue Saint-Martin, Paris).

II.—TELEPHONE TRANSMISSION REFERENCE SYSTEMS.

(Les systèmes de référence pour la transmission téléphonique, Haupteichkreise.)

Each system is composed of a transmitting system, an artificial line and a receiving system complying with the following conditions :—

(1) TRANSMITTING SYSTEM.

Definition of the Acoustic Input to the Transmitter.

In order to simplify the definition of the reference system, it is useful to start with the sound pressure rather than with the acoustic power. For the transmitter the ratio of the voltage delivered to the input of the reference artificial line to the uniform sound pressure on the diaphragm of the reference transmitter is chosen as the measure of efficiency. Hence it is necessary to fix the essential external mechanical dimensions of the reference transmitter and the manner in which it is to be used. (*See below.*)

Method of measuring the Acoustic Input to the Transmitter.

For the measurement of sound pressure any reliable method may be used (*e.g.*, Thermophone, Rayleigh Disc, or compensation methods).

Maximum permissible Acoustic Power for which the Transmitter is to be constructed.

The maximum acoustic pressure depends upon the permissible non-linear distortion. It has been found that when the types of transmitters and receivers mentioned below, together with suitable

amplifiers, are used, no appreciable non-linear distortion is produced over the range of sound pressure normally occurring.

The value of the Output Impedance of the Transmitting System.

In order to have all required corrections in a positive direction it is convenient to select 600 ohms (zero angle) as the output impedance of the transmitting system. A tolerance of $\pm$ 5 per cent. and an angle not greater than $\pm$ 10° may be permitted over the frequency range 100 to 5000 p : s.

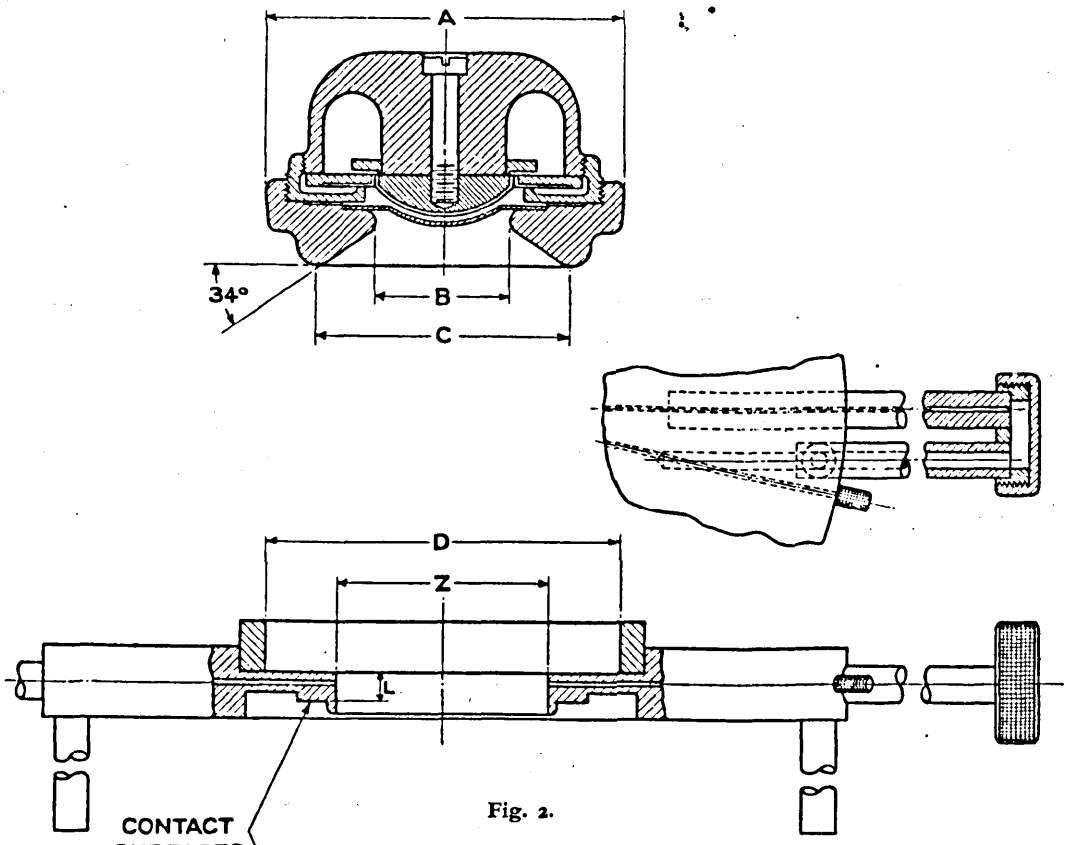


Fig. 2.

Fig. 1.

A	6·667 CM.
B	2·540 CM.
C	4·7625 CM.
D	6·670 CM.
L	0·490 CM.
N	4·286 CM.
P	0·851 CM.
Z	3·968 CM.

Section of Electro-dynamic Receiver, Condenser Transmitter, and Acoustic Coupling Device.

Adjustment of the Efficiency of the Transmitting System.

The output of the transmitting system must be adjustable in such a manner that its value can be assured with an accuracy of at least 0.02 néper or 0.2 decibel.

This adjustment must be possible between limits of — 1 to + 1 néper or between the limits — 10 to + 10 decibels.

Ratio between the Acoustic Pressure and Voltage (taken respectively at the Input and Output of the Transmitting System) defining the Zero Point of the Transmitting System.

The zero point of the transmitting system should approximate to that of commercial standard systems in general use. (*See later.* Normal adjustment of the " SFERT.")

Band of Frequencies in which the Ratio must be Constant. Permissible Variations of this Ratio within this Band of Frequencies.

The variations of this ratio must not exceed ± 0.2 néper or ± 2 decibels in the frequency range between 100 and 5000 p : s.

Maximum permissible Non-Linear Distortion (*a*) for the Maximum Power, (*b*) for a given Fraction of this Power.

The maximum acoustic pressure on the transmitter depends on the permissible non-linear distortion. Experience has shown that for normal intensity the use of the types of transmitter and of receiver specified below and associated with suitable amplifiers, does not give rise to any appreciable non-linear distortion.

Method of Construction of Transmitting System satisfying the required Conditions.

A transmitting system, composed of a condenser transmitter with stretched metallic diaphragm, and associated with a suitable amplifier, would satisfy the above conditions. Any other type of transmitter satisfying equally well the above conditions would be accepted. The essential dimensions of the condenser transmitter are indicated in Fig. 1. To compensate for the variations which may occur a regulating device should be included in the transmitting system.

(2) REFERENCE ARTIFICIAL LINE.

Characteristic Impedance of the Reference Artificial Line.

The reference artificial line must have a characteristic impedance of 600 ohms (zero angle). A tolerance of ± 1 per cent. and an angle not greater than ± 2° may be permitted over the frequency range 100 to 5000 p : s.

Adjustment of the Attenuation of the Reference Artificial Line.

The attenuation of the reference artificial line must be adjustable by steps of 0.02 néper or 0.2 decibel between the limits 0—6 népers or 0—60 decibels.

(3) REFERENCE RECEIVING SYSTEM.

Definition of the Acoustic Output furnished by the Receiver.

The sound pressure delivered at the end of a metallic acoustic coupler is regarded as a measure of the acoustic output. The essential dimensions of this coupler are given in Fig. 2. It is necessary to fix certain essential dimensions of the receiver in the same way as for the transmitter, and these are also given in Fig. 2.

Method of Measuring the Acoustic Output of the Receiver.

The measurement of the sound pressure, as in the case of the transmitter, may be carried out by means of any reliable method (calibration by means of a condenser transmitter and the sound pressure compensation method are in practical use).

The Value of the Electrical Impedance at the Input of the Receiving System.

The impedance of the receiving system must be 600 ohms (zero angle). A tolerance of $\pm$ 5 per cent. and an angle not greater than $\pm$ 10° over the frequency range 100 to 5000 p : s may be permitted.

Adjustment of the Efficiency of the Receiving System.

The efficiency of the receiving system must be adjustable in such a manner that its value can be assured to an accuracy of at least 0.02 néper or 0.2 decibel.

This adjustment must be possible between limits of $-$ 1 to $+$ 1 néper or $-$ 10 to $+$ 10 decibels.

Ratio between the Voltage and Acoustic Pressure (taken respectively at the Input and Output of the Receiving System) defining the Zero Point of the Receiving System.

The efficiency of the reference receiving system is *determined* by the ratio of the sound pressure of the acoustic coupler to the input voltage across the receiving system. The zero point of the receiving system should approximate to that of commercial standards in general use. (*See later.* Normal adjustment of the "SFERT.")

Frequency Range over which this Ratio must remain Constant.

Permissible Variations of the Ratio in this Frequency Range.

The variations of this ratio must not exceed $\pm$ 0.4 néper or $\pm$ 4 decibels for frequencies lying between 300 and 3000 p : s or $\pm$ 1 néper or $\pm$ 10 decibels for frequencies between 100 and 5000 p : s.

Maximum Non-Linear Distortion permissible in the Receiving System.

(*a*) For Maximum Power, (*b*) For a given Fraction of this Power.

The maximum acoustic pressure on the transmitter depends on the permissible non-linear distortion. It has been found that for sounds of normal intensity the use of the types of transmitter and receiver specified below, when associated with suitable amplifiers, does not give rise to any appreciable non-linear distortion.

Method of Construction of a Receiving System satisfying the required Conditions.

Any system satisfying the above conditions is admissible.

The earpiece of the receiver must have certain essential dimensions which are indicated in Fig. 2. Also the volume of the cavity bounded by the receiver diaphragm, the walls of the earpiece and the plane of contact with the acoustic coupler must be approximately the same as indicated in Fig. 2.

III.—WORKING STANDARDS.

(Les étalons de travail, Arbeitseichkreise.)

Working standards are systems calibrated by voice and ear tests with a telephone transmission reference system.

They are composed of a transmitting system, an artificial line and a receiving system.

The transmitting and receiving systems should have transmission characteristics similar to those of commercial apparatus.

Although it is more convenient to obtain working standards by choosing them from the usual types of commercial apparatus, it is permissible to use apparatus different from commercial types.

Appendix I, later, describes a working standard employing a carbon transmitter (" SETAC "), the method of comparing this standard with the " SFERT," gives advice on the use of such a standard, together with all information necessary for its periodic re-calibration, and despatch, for this purpose, to the " SFERT " Laboratory.

Appendix II, later, describes a working standard without a carbon transmitter (" SETEM ") using amplifiers and the method of comparing this standard with the " SFERT," and gives advice on the use of such a standard, together with all information necessary for its periodic re-calibration.

Bearing in mind the definitions adopted by the C.C.I. for the reference equivalent of a system or a component part thereof, when making telephonometric measurements in order to determine a reference equivalent, it is necessary to compare the system, or the component part concerned either with the distortionless " SFERT " or with a working standard, which has been calibrated against the distortionless " SFERT," it being understood that the working standard is distortionless or, if not, that its distortion characteristics are similar to those of the system or component part which is being tested.

The working standards, known as " SETAC " or " SETEM," described in Appendices I and II of the "Livre Jaune," should continue in use pending the realisation, in various countries, of working standards which would be of a sufficiently stable type or else consisting of component parts and lines, physically defined and incorporating distortion characteristics similar to those inherent in commercial apparatus used in various countries.

Administrations and Operating Companies are therefore advised to select from their ordinary commercial apparatus, those whose efficiency shows as small a variation as possible when compared with one of the above-mentioned working standards; as a matter of information it may be said that a variation of ± 2 db from the mean value is considered permissible.

The apparatus selected because of its stability should be regarded as primary working standards, which should be frequently calibrated either against the distortionless " SFERT " or against a working standard, previously calibrated against the distortionless " SFERT."

In this manner experimental data will become available, enabling one to ascertain if, in the future, it will be possible to construct working standards from commercial apparatus.

Administrations and Operating Companies, who do not possess working standards, should investigate the stability of their commercial apparatus by the aid of the " SFERT " Laboratory or by assistance of an Administration or Operating Company, who have a standard, which has been calibrated by the " SFERT."

RECOMMENDATIONS REGARDING THE CALIBRATION OF REFERENCE SYSTEMS AND WORKING STANDARDS.

A. COMPARISON OF REFERENCE SYSTEMS WITH THE MASTER REFERENCE SYSTEM, AND THE PERIODS AT WHICH SUCH COMPARISONS SHOULD BE MADE.

As a reference system, complying with the above-mentioned conditions, may differ from the Master System, the first calibration should be made in the Master System Laboratory, using the complete transmitting and receiving systems (including the amplifiers) of the system to be calibrated. The first calibration will indicate whether subsequently it will be sufficient to calibrate only the transmitters and receivers of the reference system by comparison with those of the Master System.

Until thorough experience of these tests has been obtained, it is desirable to repeat these calibrations every nine months, in order that they may be carried out under varying atmospheric conditions.

B. CALIBRATION OF WORKING STANDARDS REFERRED TO THE "SFERT."

(*See* Appendices I and II, later.)

C. NORMAL ADJUSTMENT OF THE "SFERT."

Determination of zero levels of the transmitting and receiving systems of the Master Reference System.

The characteristic curves of the transmitter and receiver of the "SFERT" will be expressed, respectively, in terms of one volt per bar for the transmitting system, and one bar per volt for the receiving system. The values, for the different frequencies to be considered, of the ratios of volts per bar and of bars per volt, proposed for characterising the zero level of the transmitting system and receiving system, with and without distortion, and the values in bars per bar for the complete reference system containing a line of zero decibels, are given in Tables I to V below. With each of these values is given the number of decibels *determined* by their ratio to one volt per bar for the transmitting system, and to one bar per volt for the receiving system, and to one bar per bar for the complete system.

The maximum permissible deviations of the characteristic curves of the system, and of its components, for any frequency must not exceed $\pm$ 0.1 néper or $\pm$ 1.0 decibel from the values given in the tables attached. (For frequencies between 100 and 5000 p : s).

The arithmetic means of the values given in Tables I to V, for frequencies between 200 and 3600 p : s inclusive, will be taken as the specification for regulation of the Master System without distortion, and for its components. In cases of deviation between the characteristic curves of the transmitting and receiving systems without distortion, and the values given in the attached tables, the setting of the potentiometer for each element will be changed by a quantity equal to the mean of the differences, in decibels, between the test results at the time considered, and the values given in the attached tables (for frequencies given in these tables which are between 200 and 3600 p : s).

For the transmitting system and for the receiving system with distortion, the maximum permissible deviation for any frequency is the same as in the preceding case for components without distortion. To ensure that regulation at any instant takes into account deviations with respect to the values given

in the attached tables, the arithmetic mean in decibels of the deviations obtained for the three frequencies 800, 1000 and 1300 p : s will be taken.

The characteristic curves in Figures 1 to 4 below furnish an illustration of the working of the transmitting and receiving systems of the " SFERT " (with and without distortion); the dotted curves (numbered 2) represent the zero levels of the transmitting and receiving systems.

In order to reduce the noise in the Master Reference System to a negligible quantity, periodic measurements are made of the noise produced by the elements of the " SFERT." This procedure is also followed in order to determine the noise which may be produced by the condenser microphone under operating conditions.

Rules have been laid down for obtaining the characteristic curves of the "SFERT" and its components, and for exchanging test results every six months between New York and Paris. For these purposes it is necessary to possess the following information :—

1. Characteristic curves of each condenser transmitter and of its associated amplifier.
2. Combination of the characteristic curve of one of the condenser transmitters with that of its associated amplifier.
3. Characteristic curves of each electro-magnetic receiver (moving-coil type) and of its associated amplifier.
4. Combination of the characteristic curve of one of the electro-magnetic receivers with that of the associated amplifier.
5. The characteristic curves obtained with one of the condenser transmitters and one of the electro-magnetic receivers, when distorting networks are inserted in the corresponding amplifiers.

The characteristic curves should be expressed in decibels, and referred to one volt per bar for the transmitters, and to one bar per volt for the receivers. Further, the test results of one of the condenser transmitters with four thermophones will be given.

TABLE I.

CHARACTERISTIC VALUES OF THE TRANSMITTING SYSTEM.

Frequency.	Volts per bar.	Decibels.	Frequency.	Volts per bar.	Decibels
100	0·0272	—31·3	1 800	0·0263	—31·6
200	0·0272	—31·3	2 100	0·0269	—31·4
300	0·0260	—31·7	2 400	0·0269	—31·4
400	0·0257	—31·8	2 700	0·0275	—31·2
500	0·0253	—31·9	3 000	0·0284	—30·9
600	0·0253	—31·9	3 300	0·0294	—30·6
700	0·0253	—31·9	3 600	0·0305	—30·3
800	0·0253	—31·9	4 000	0·0323	—29·8
900	0·0257	—31·8	5 000	0·0337	—29·4
1 000	0·0257	—31.8	6 000	0·0309	—30·2
1 100	0·0257	—31·8	7 000	0·0229	—32·8
1 200	0·0257	—31·8	8 000	0·0165	—35·7
1 300	0·0260	—31·7	9 000	0·0121	—38·4
1 500	0·0263	—31·6	10 000	0·0092	—40·7

Decibels referred to 1 volt per bar.

Frequency range	Average value in volts per bar.	Average value in decibels.
500–2 500 p : s	0·0259	—31·7
200–3 600 p : s	0·02656	—31·5

TABLE II.

CHARACTERISTIC VALUES OF THE RECEIVING SYSTEM.

Frequency.	Bars per volt.	Decibels.	Frequency.	Bars per volt.	Decibels.
100	16·4	24·3	1 800	17·6	24·9
200	17·4	24·8	2 100	17·8	25·0
300	17·6	24·9	2 400	16·2	24·2
400	17·2	24·7	2 700	14·7	23·3
500	17·0	24·6	3 000	13·3	22·5
600	16·8	24·5	3 300	12·3	21·8
700	16·8	24·5	3 600	11·1	20·9
800	16·8	14·5	4 000	10·5	20·4
900	16·8	24·5	5 000	12·3	21·8
1 000	17·0	24·6	6 000	17·2	24·7
1 100	17·0	24·6	7 000	14·5	23·2
1 200	17·2	24·7	8 000	14·5	23·2
1 300	17·2	24·7	9 000	14·5	23·2
1 500	17·2	24·7	10 000	10·9	20·7

Decibels referred to 1 bar per volt.

Frequency range.	Average value in bars per volt.	Average value in decibels.
500–2 500 p : s	17·03	24·6
200–3 600 p : s	16·28	24·2

TABLE III.

CHARACTERISTIC VALUES OF THE "SFERT" WITH 0 DECIBEL IN CIRCUIT.

Frequency.	Bar per volt.	Decibels.	Frequency.	Bar per volt.	Decibels.
100	0·446	—7·0	1 800	0·462	—6·7
200	0·474	—6·5	2 100	0·479	—6·4
300	0·458	—6·8	2 400	0·435	—7·2
400	0·441	—7·1	2 700	0·404	—7·9
500	0·431	—7·3	3 000	0·378	—8·4
600	0·426	—7·4	3 300	0·362	—8·8
700	0·426	—7·4	3 600	0·338	—9·4
800	0·426	—7·4	4 000	0·338	—9·4
900	0·431	—7·3	5 000	0·415	—7·6
1 000	0·436	—7·2	6 000	0·531	—5·5
1 100	0·436	—7·2	7 000	0·332	—9·6
1 200	0·441	—7·1	8 000	0·239	—12·5
1 300	0·446	—7·0	9 000	0·175	—15·2
1 500	0·452	—6·9	10 000	0·100	—20·0

Decibels referred to 1 bar per bar.

Frequency range.	Average value in bar per bar.	Average value in decibels.
500–2 500 p : s.	0·441	—7·1
200–3 600 p : s.	0·429	—7·4

TABLE IV.

CHARACTERISTIC VALUES OF THE TRANSMITTING SYSTEM WITH DISTORTION NETWORK NO. 1.

Frequency.	Volts per bar.	Decibels.	Frequency.	Volts per bar.	Decibels.
100	0·0618	—24·2	1 800	0·0169	—25·5
200	0·0275	—31·2	2 100	0·00977	—40·2
300	0·0090	—40·9	2 400	0·00610	—44·3
400	0·0143	—36·9	2 700	0·00408	—47·8
500	0·0204	—33·8	3 000	0·00299	—50·5
600	0·0263	—31·6	3 300	0·00202	—53·9
700	0·0316	—30·0	3 600	0·00133	—57·6
800	0·0390	—28·2	4 000	0·000611	—64·3
900	0·0483	—26·3	4 400	0·0000751	—82·5
1 000	0·0741	—22·6	5 000	0·000531	—65·5
1 100	0·139	—17·1	6 000	0·00104	—59·7
1 160	0·185	—14·6	7 000	0·00100	—60·0
1 200	0·182	—14·8	8 000	0·000824	—61·7
1 300	0·118	—18·6	9 000	0·000684	—63·3
1 500	0·039	—28·2	10 000	0·000575	—64·8

Referred to 1·0 volt per bar.

TABLE V.

CHARACTERISTIC VALUES OF THE RECEIVING SYSTEM WITH DISTORTION NETWORK NO. 1.

Frequency.	Bars per volt.	Decibels.	Frequency.	Bars per volt.	Decibels.
100	2·79	8·9	1 200	43·5	32·8
200	5·4	14·6	1 300	24·0	27·6
300	7·8	17·8	1 500	12·0	21·6
400	10·4	20·3	1 800	5·93	15·5
500	13·3	22·5	2 100	3·39	10·6
600	17·4	24·8	2 400	2·07	6·3
700	22·5	27·0	2 700	1·259	2·0
800	29·3	29·3	3 000	0·813	—1·8
900	44·5	33·2	4 000	0·248	—12·1
1 000	96·3	39·7	5 000	0·133	—17·5
1 060	150·0	43·5	6 000	0·100	—20·0
1 100	116·3	41·3			

Decibels referred to 1·0 bar per volt.

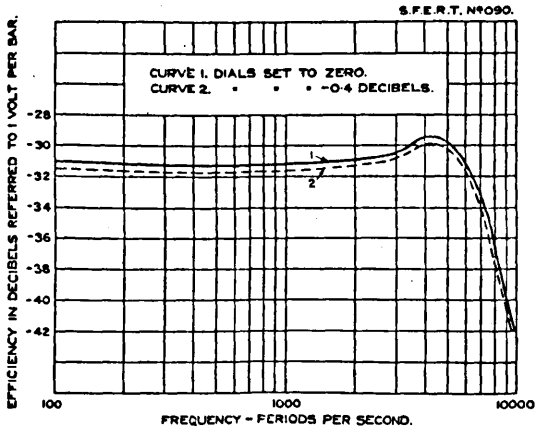


FIG. 1.—Characteristic curve of the working of the transmitting system (without distortion) of the "SFERT." Standard microphone No. 3824.

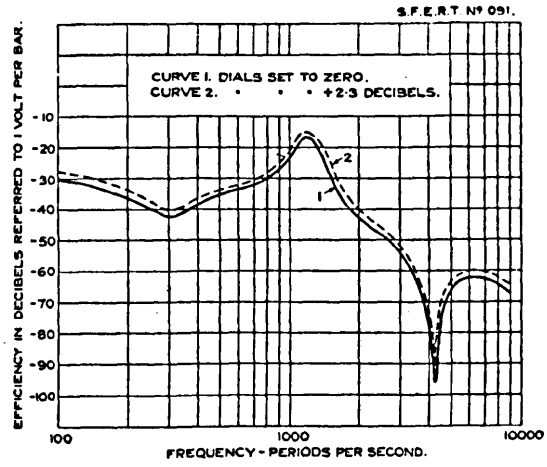


FIG. 2.—Characteristic curve of the working of the transmitting system (with distortion) of the "SFERT." Standard microphone No. 3824.

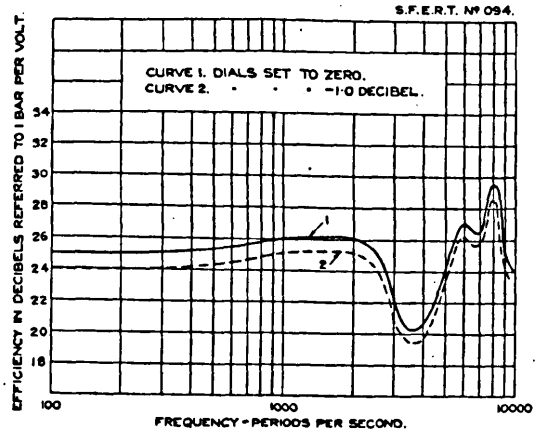


FIG. 3.—Characteristic curve of the working of the receiving system (without distortion) of the "SFERT." Standard receiver No. 22.

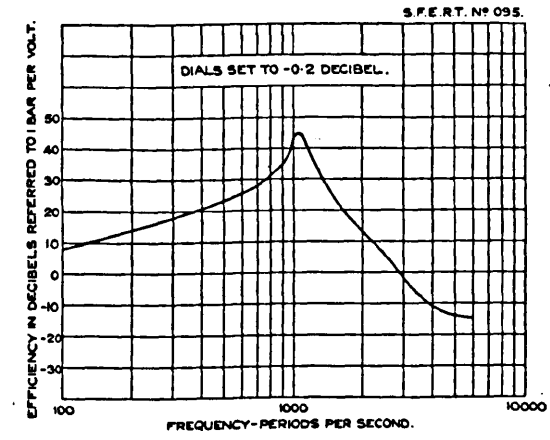


FIG. 4.—Characteristic curve of the working of the receiving system (with distortion) of the "SFERT." Standard receiver No. 22.

Replacing the Human Voice and Ear by Mechanical Devices in Telephonometric Tests.

The International Consultative Committee—

Considering :—

That experiments, looking towards replacing the human voice in telephonometric tests by, for example, a gramophone disc or a receiver operating on a mixture of frequencies, have not yet resulted in the design of a mechanical device which can replace the human voice with certainty.

Unanimously advises :—

(1) That, for the present, it is essential that all telephonometric tests carried out at the " SFERT " Laboratory continue to be made with voice and ear ;

(2) That, nevertheless, it is desirable to establish apparatus for telephonometric tests, so constructed that in the future all such tests can be made by the aid of such apparatus without recourse to the voice and ear;

(3) That the study of this question should be continued with the object of finding apparatus to replace the voice and the ear;

(4) That the various Administrations and Operating Companies be invited to make experiments in this field and to communicate their findings to the General Secretary of the C.C.I.

As a guide to the Administrations and Operating Companies in their experiments, some fundamental principles concerning the requirements which such apparatus should fulfil in the light of experience gained up till now are given below under the heading " Guiding Principles."

Note.—Meanwhile it goes without saying that Administrations and Operating Companies will be able, if they wish, to use the apparatus which they develop to test bulk deliveries of telephone apparatus supplied by their contractors, provided the results obtained with such apparatus agree with those obtained when the voice and ear testing method is used.

A. GUIDING PRINCIPLES IN STUDYING APPARATUS INTENDED TO REPLACE THE HUMAN VOICE IN TELEPHONOMETRIC TESTS.

(1) The results obtained with the apparatus shall correspond as nearly as possible to those obtained by voice tests.

(2) Concerning the band of frequencies transmitted, it is desirable that it shall comprise the main part of the band used in a conversation. It is desirable to aim at a frequency band from 100 p : s to 6 000 p : s.

(3) It is important that the sound field in front of the apparatus should be distributed in a similar manner to that of the mouth of a speaker.

(4) The apparatus should be capable of producing, without linear distortion, a power comparable to the maximum speech power used in a commercial telephone conversation.

(5) Experience has shown that not only is it necessary that the diagram of distribution of the sound energy emitted by the apparatus shall correspond to that of the sound of the human voice, but it is also essential that the amplitude of the sound varies in a similar manner to that of a continuous conversation.

(6) The apparatus should be constant and capable of exact reproduction.

B. GUIDING PRINCIPLES IN STUDYING APPARATUS INTENDED TO REPLACE THE HUMAN EAR IN TELEPHONOMETRIC TESTS.

(1) The results obtained with the apparatus shall correspond as nearly as possible to those obtained when listening with the human ear.

(2) It is desirable that the band of frequencies received shall comprise the main part of the band used in conversation. It is desirable to aim at a frequency band from 100 p : s to 6000 p : s.

(3) The acoustic impedance presented to the receiver should be the same as would be presented by the human ear.

(4) The sensitivity of the apparatus should be comparable with that of the human ear.

(5) The apparatus should be constant and capable of exact reproduction.

SPECIAL PRECAUTIONS TO BE TAKEN WHEN MEASURING THE REFERENCE EQUIVALENTS OF HAND-MICROTELEPHONES.

Test of Subscriber's Apparatus.

In order that telephonometric tests of various types of hand-microtelephones may give consistent and comparable results, the testing conditions must be clearly defined and must, as nearly as possible, approach normal working conditions.

The most important points to observe are the distance between the mouth and the microphone diaphragm and the angle at which the latter is inclined. Measurements have therefore been made on

a large number of individuals with the object of establishing the characteristic dimensions of an average subscriber and the position in which he holds the microtelephone to his ear during a conversation. Such measurements have been made in various countries by means of a device for measuring the dimensions of the head.

This device (Fig. 5) is used in the manner shown in Fig. 5A. It consists of a telephone receiver, through which is sent a complex frequency tone and to which are fixed a system of graduated scales. The device is held in the plane of the ear and mouth, the individual placing the receiver to his ear as he would normally do. The distance d_1 between the centre of the ear and the line of the lips and the distance d_2 to the centre of the mouth are read on the scales. By means of the abacus (Fig. 6) the following data are deduced :—

(1) The distance δ between the centre of the ear and the middle of the mouth.

(2) The angle α between the plane of the orifice of the telephone receiver and the straight line from that orifice to the middle of the mouth.

The distance l between the middle points of the orifices of telephone receivers placed against the two ears respectively, is measured (l thus being the distance between the centres of the ears). The angle β between the plane through the orifice of the telephone receiver placed against the ear, and the " direction of speech " is computed; in other words, the direction of the line of intersection of the median plane of the subscriber's head with an imaginary plane, passing through the centres of his ears and the middle of his mouth.

The value of β is obtained from the formula :—

$$\beta = \text{arc sin } \frac{l}{2\delta} - \alpha$$

The abacus (Fig. 7) gives a practical method of graphic representation and records the results of measurements of δ and α made in the United States of America.

Administrations and Operating Companies are asked to make similar measurements and to communicate to the C.C.I. the mean values found for α, β and δ.

For the present the C.C.I. recommends the following provisional values :—

$\alpha = 15°30.$
$\beta = 18°.$
$\delta = 14$ cm.

These are the average values observed in the United States and in Great Britain.

Using these values it is possible to determine the position of a guard ring to fix the position of the mouth of the operator who is testing a microtelephone. The plane of the guard ring must be at right angles to the symmetrical plane of the instrument and its centre must be located in that plane.

Its position is defined by the following geometrical construction in the symmetrical plane of the instrument. The middle point of the orifice of the receiver is taken as the origin. From this origin a straight line is drawn making an angle α with the plane of the orifice of the receiver and of length δ. The point, thus found, is the centre of the guard ring, which should coincide with the middle point of the lips.

The intersection of the plane of the ring with the symmetrical plane will be a straight line, perpendicular to the direction of conversation above defined; in other words, the perpendicular to the straight line will make an angle β with the plane of the receiver.

The position of the guard ring is thus definitely fixed with respect to the instrument.

It remains to determine the position of the guard ring in space during telephonometric tests. It is assumed that the operator holds his head erect whilst speaking, that is to say, that the median plane of his head is vertical. The centre of the ring then falls in that plane and the plane of the ring is perpendicular to it.

It is, however, also necessary to determine the angle of the ring with respect to the horizontal plane. This is taken as 45°, which corresponds to a normal posture during conversation, the head being slightly inclined forward.

Note I.—It should be noted that the position of the guard ring, thus defined, has been fixed without reference to the angle of the diaphragm of the microphone and does not necessarily correspond to the best operating conditions of the latter.

Note II.—In order to compare the efficiency of the Solid Back type of microphones, tested under conditions specified for that class of instruments (the upper lip touching the mouthpiece), with that of hand-microtelephones tested as outlined above, it is necessary to apply a correction to the tests on the Solid Back microphone in order to allow for the fact that, in practice, the subscriber speaks with his mouth a certain distance away from the mouthpiece. Administrations in countries, ordinarily using this type of instrument (United States and Great Britain) should come to an agreement regarding the separation which should be considered as an average distance between the mouth and mouthpiece.

Note III.—If, when the hand-microtelephone is in the correct position described above, the receiver is near the ear, care must be taken to ensure that the speech volume remains constant; the receiver should, therefore, not be pressed against the ear of the operator. Alternatively, the receiver may be disconnected and replaced by a similar receiver placed face downwards on the table and having the same impedance.

The volume indicator is connected to the standard, and when the operator speaks into the hand-microtelephone he is inclined to vary the speech power on account of the side tone in the receiver. This is most likely to occur in instruments without anti-side tone circuit.

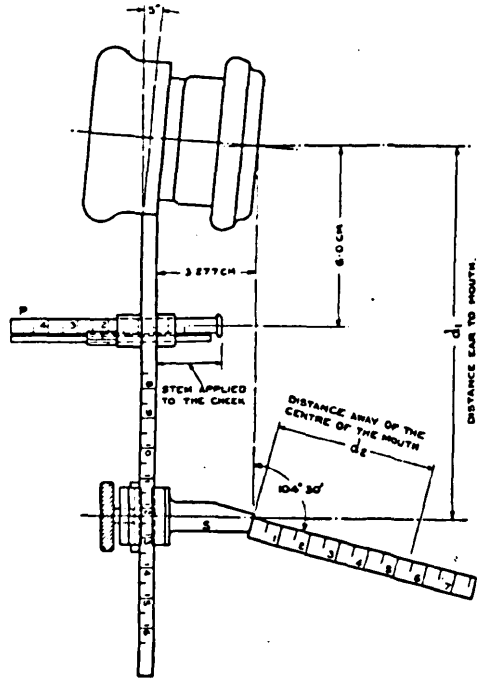


FIG. 5.—Device for measuring head dimensions.

Note IV.—It is essential that the guard ring and its mounting should be of light construction in order not to cause any disturbance in the acoustic field in front of the microphone. It is equally important that the pressure on the housing of the microphone should not interfere with the mechanical and electrical properties of the instrument.

A device similar to that shown in Fig. 8 and Fig. 8A is recommended.

DEFINITION AND MEASUREMENT OF VOLUME.

Speech Volume and "Impulsions."*

A. GENERAL.

In transmitting electrical energy over lines it is customary to consider the following magnitudes :—

1. **The power,** which is measured by a wattmeter.

2. **The maximum energy consumed** during a certain period, say, for instance, one-quarter of an hour. This amount is measured by a maximum demand indicator (Indicateur de Maximum—Höchstleistungsmesser).

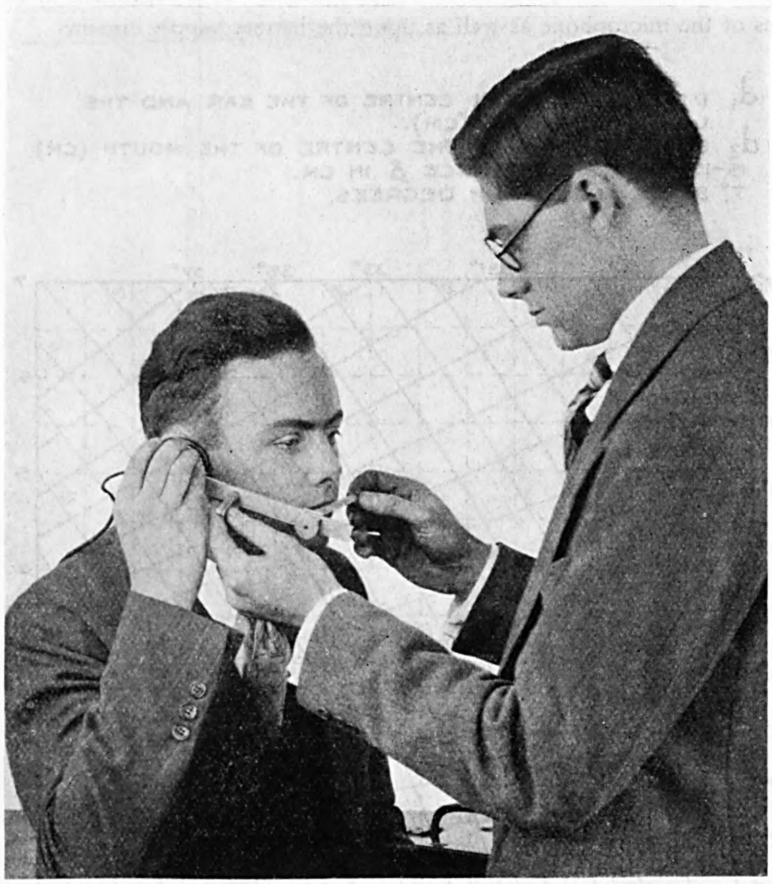


FIG. 5A.

In telephonic transmission the following magnitudes must be considered :—

1. **The Acoustic Pressure** of a free wave, the effective value of which, p, is expressed in bars (dynes/cm^2).

2. **The Intensity of Sound** (l'intensité sonore—Schallintensität) which, in the case of plane or spherical acoustic waves, if propagated freely with a velocity a through a medium of density (masse spécifique—Dichte) ρ is equal to :—

$$\frac{p^2}{a\rho}$$

(In air the product $a\rho$ is very nearly equal to 42 in the C.G.S. system). The sound intensity has the dimensions of power per unit area.

* This text replaces pp. 59-73 of the *Livre Jaune* (English Edition, pp. 35-39), entitled "General Considerations of Volume Indicators."

3. **The Acoustic Pressure on the Diaphragm of the Microphone.** When an acoustic wave strikes the diaphragm of a microphone the ratio, k, between the acoustic pressure on the diaphragm and the pressure of the free wave, is a function of the frequency as well as of the dimensions and shape of the microphone (with its mouthpiece). The value of k may, for example, vary from 1 to 2, when the acoustic wave strikes a spherical body. The ratio, k, is greater than 2 when the microphone with its mouthpiece is of a suitable shape or when there is resonance between the frequency of the incidental wave and the natural frequency of the mouthpiece or the diaphragm.

4. **The Voltage at the Terminals of the Microphone.** The voltage at the terminals of the microphone is a function of the acoustic pressure on the diaphragm. It is dependent upon the acoustic and electric properties of the microphone as well as upon the battery supply circuit.

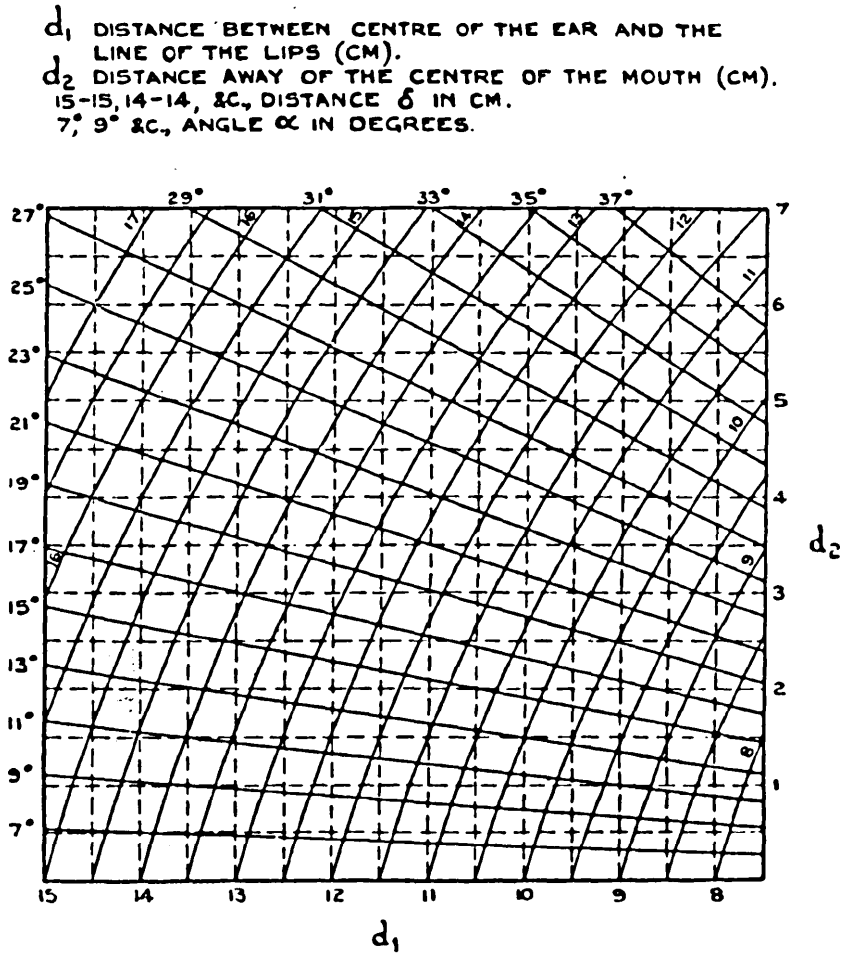


FIG. 6.—Chart for use with head measuring device.

5. **The Electromotive Force of the Microphone.** The value of this electromotive force can be deduced from a measurement of the voltage at the terminals of the microphone, if the internal impedance of the microphone and the external circuit impedance are known. It can also be measured directly by the following substitution method.

The first stage of this measurement consists in connecting the microphone to a vacuum tube voltmeter. A sinusoidal acoustic wave of known pressure and frequency is applied to the diaphragm and the deflection of the needle on the vacuum tube voltmeter is noted.

During the second stage of the test the acoustic pressure is removed and a difference of potential is applied in series with the microphone, said potential being obtained from a potentiometer, the current supply of which has the same sinusoidal frequency. The potentiometer is adjusted until the same deflection on the instrument is obtained as in the first stage of the measurement.

The potential across the terminals of the potentiometer is then the desired electromotive force. It is essential that the resistance of the potentiometer should be non-inductive and be small compared with that of the microphone. The leads between the potentiometer and the microphone should also be short and have no appreciable capacity.

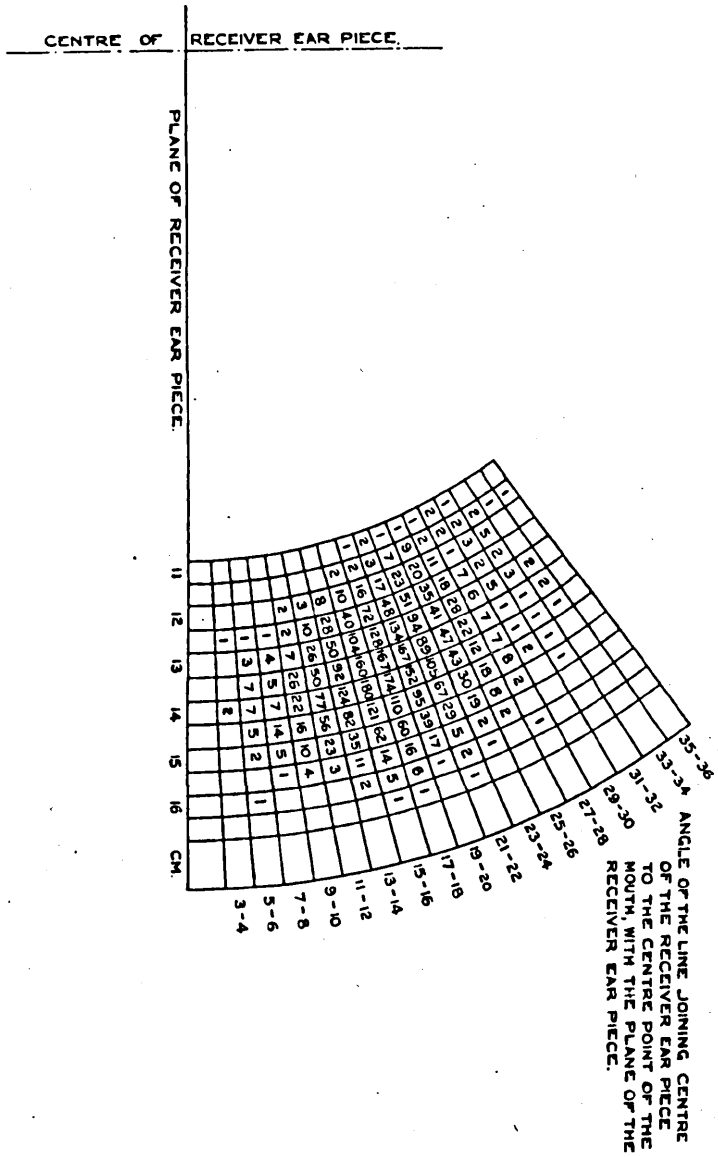
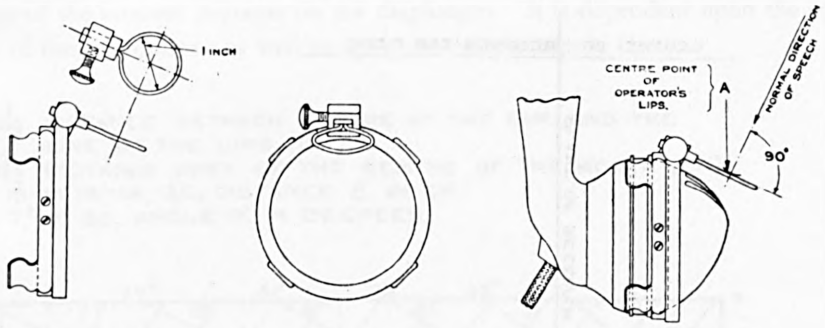


Fig. 7.—Chart of head measurements.
(Men and women) total number of measurements: 3889.

In measurements, where one may assume a linear functioning of the microphone (the normal working conditions without excessive distortion), the output voltage for a given frequency is proportional to the acoustic pressure of the free wave.

The condenser microphone, the electro-dynamic and the quartz piezo-electric microphone all have practically linear characteristics. On the other hand, the carbon microphone, for example, especially when subjected to a relatively intense acoustic pressure, has not a linear characteristic; in this case the ratio between the voltage and the acoustic pressure (the absolute efficiency of the microphone) depends on the acoustic pressure.

The human voice exerts an acoustic pressure of a complex form on the microphone. Assuming that the wave form itself ought to be faithfully reproduced in telephonic transmission, one is obliged to consider the important range of amplitude occurring.



1. EXAMPLE OF GUARD RING FOR TESTS OF HAND MICROTELEPHONES.

2. FIXING OF THE GUARD RING ON A HAND MICROTELEPHONE.

FIG. 8.

In certain telephone transmission problems—for example, those involved in the relaying by wire of radio broadcast transmissions or even radio telephone circuits—it is necessary to ensure that the voltage, corresponding to speech currents, falls between a minimum value (depending on the amplitude of the noise, created by external influence) and a maximum value (the amplitude of overloading, which gives rise to non-linear distortion phenomena).

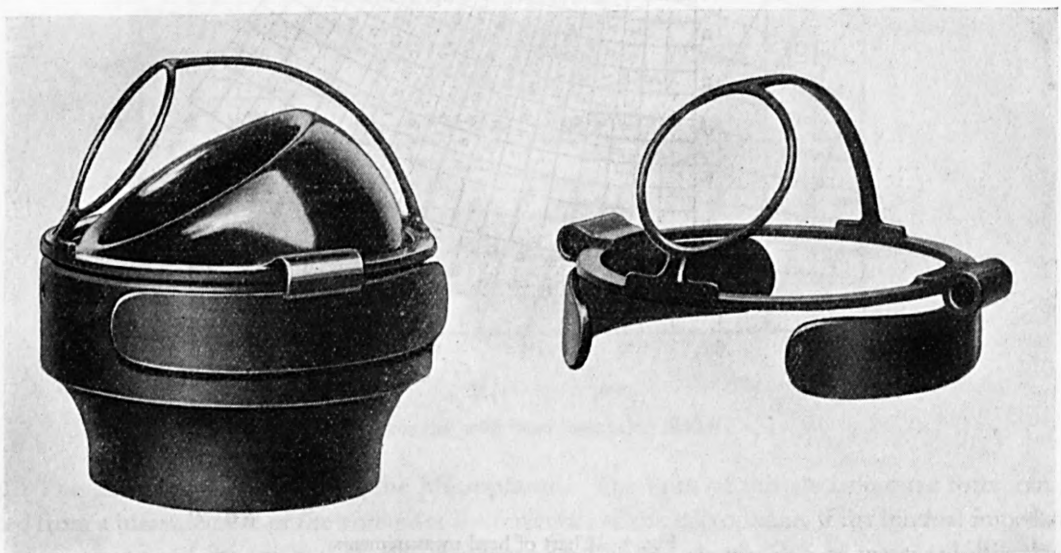


FIG. 8A.

In other telephone transmission problems experience has shown that it is necessary to maintain the voltages, corresponding to voice currents, within narrow limits. Such is the case, for example, in measurements by voice and ear (telephonometry).

B. GENERAL DEFINITION OF VOLUME.

It is useful to have a general expression to indicate what is passing in a circuit during transmission. The expression generally used is the word " Volume " (Volume—Volümen).

It is also useful to have an instrument by means of which it is possible to ascertain that the volume in a continuous telephone conversation or in a broadcast transmission remains above the limit at which noise becomes disturbing and below the point where non-linear distortion is likely to be troublesome. This instrument is known as a " Volume Indicator."*

Several methods may be used in measurements of volume. Depending upon the principle involved the instruments may be classified as follows :—

Type of Apparatus.	Integration Time in Milliseconds	Time (Milli-seconds) required for needle to return to zero position.	Summation Law of Frequency Components.	Field of use.
*Speech Power Indicator (Volume Indicator).	200	200	Square	Measurement of the speech power of a conversation.
Average Impulse Indicator	200	2000	Linear	Measurement of average impulses, transmitted by a conversation, by a series of logatomes or by a single logatome.
Maximum Impulse Indicator.	20	2000	Linear	Peak measurements to prevent overloading.

All of the above instruments are of the needle indicating type, permitting readings of volume.

There are other types, which do not measure the volume, but simply indicate when a certain volume is exceeded. With the latter type (for example, one using a Neon lamp) it is possible to detect overloading of very short duration.

C. CHARACTERISTICS RECOMMENDED FOR SPEECH POWER INDICATORS AND PEAK INDICATORS.

The International Consultative Committee—

Unanimously advises :—

That it is desirable to establish speech power indicators and peak indicators, fulfilling the following specifications :—

I. Speech power indicator† capable of measuring the speech volume in a telephone circuit (metallic or radio) during the course of a continuous conversation.

(1) In order to measure speech volume at a point in a circuit during a continuous conversation an instrument is used, the integration period (transient period after circuit is closed) of which is 200 milliseconds, corresponding to the average duration of a logatome.

* TRANSLATOR'S NOTE.—Although this instrument is called in practice, and is known commercially as a " Volume Indicator," the phrase " Indicateur de puissance vocale " has in translating been rendered as " Speech Power Indicator " in order to avoid confusion with the term " Volume Indicator." The latter is a special form of " Speech Power Indicator " which forms an integral part of the " SFERT."

† L'indicateur de puissance vocale, used in the " SFERT " laboratory is conventionally referred to as " Volume Indicator." It is an integral part of the " SFERT."

The integration period is the minimum time required for a sinusoidal E.M.F. to be applied to the terminals of the instrument in order that its needle shall give the same deflection within 2 db as it would if the same E.M.F. were applied indefinitely.

(2) The time required for the needle to return to zero should be regulated to equal the integration period, *i.e.*, 200 milliseconds.

(3) *Scale.* The instrument should be graduated in transmission units (népers or db) and give a direct reading, in these units, of the speech volume measured with reference to the normal speech volume as hereinafter defined. (*See* the new text of Annex No. 3 to Appendix I, entitled " Note concerning working standards' system, using carbon microphone (" SETAC ").)

(4) *Use of Calibration.* This type of instrument must be calibrated before any measurements are made. For calibration purposes a mark is made preferably on the scale of the measuring instrument to indicate " reference deflection." For this purpose the instrument is connected to a source of alternating current of 800 or 1000 p : s, so adjusted that it delivers a power of 6 mW into an impedance of 600 $\angle 0°$ ohms.

A calibration dial is then adjusted so that, when the reading on the transmission unit scale is zero (corresponding to the reference volume), the needle of the instrument is deflected to the reference mark.

In order to proceed to the measurement of voice volume the instrument is shunted across the circuit at the desired point and the transmission unit dial is so adjusted that the needle is deflected to the reference mark once every three seconds. The number of transmission units read on the scale are then a measure of the relative speech volume at the testing point (in terms of the reference volume).

In order to facilitate the measurement it is convenient to have a scale in transmission units, in addition to the dial, marked off on each side of the reference mark.

(5) The ballistic properties of the instrument should be such that the needle does not swing beyond its final position by more than 1 db, when the sinusoidal E.M.F. is applied to the terminals of the instrument.

(6) The frequency characteristic of the instrument should be uniform to about $\pm$ 1 db within the range of 200 to 3500 p : s in instruments intended for use on commercial telephone circuits and should also be uniform to about $\pm$ 2 db within the ranges 30 to 200 p : s and 3500 to 7000 p : s in instruments intended for use on radio broadcast relay circuits.

(7) The instrument should be so designed that the summation of the various frequency components is effected according to a square law.

(8) The input impedance of the instrument should not be less than 10000 ohms. The instrument should also be symmetrical, giving the same readings regardless of polarity.

II. Peak indicator, giving the average or maximum peak impulses during a conversation.

In principle these instruments differ from the preceding type described under I in the following respects :—

(1) The integration period is—

Either 200 milliseconds, in which case the instrument is capable of measuring the average impulses, corresponding to a logatome or a series of isolated logatomes or a portion of a continuous conversation ;

Or 20 milliseconds, in which case it is capable of measuring maximum impulses.

(2) The time required for the needle to return to zero is about 2 seconds.

(3) The instrument may be graduated in népers, decibels, volts or milliwatts.

(4) The rectification law of the voice currents is a linear, and not a square law.

Note.—For volume measurements during a radio transmission (relay of a broadcast programme by means of a telephone circuit) it is sufficient for the present to use a peak indicator, designed for a frequency band of 30 to 7000 p : s.

III. Maximum Amplitude Indicator.

Peak indicators with an integration period of 20 milliseconds or less may be regarded as true peak indicators, giving approximately the values of the maximum amplitude of the voltage applied to the terminals. Other indicators of this type are those of small inertia, such as lamps filled with rare gases, cathode ray oscillographs, kenotron voltmeters, etc.

This class of instruments is useful in ascertaining that there is no over-loading of certain vital parts, such as repeaters, echo-suppressors and the like.

IV. Comparison of a volume indicator with that used by the "SFERT" Laboratory in telephonometric measurements.

The International Consultative Committee—

Considering :—

That the volume indicator, which is an integral part of the "SFERT" in its present form is capable of regulating in a satisfactory manner the speech volume of an operator during telephonometric tests.

That, in any case, the rhythm and stability of its readings are not absolutely independent of the nature of the phrases used for telephonometric tests.

Unanimously advises :—

That final tests should be made in order to compare the "SFERT" volume indicator with various types of volume indicator; that the method to be used for these tests should include a variation of the transmitting system by steps of 5 decibels, the original deflection of the "SFERT" volume indicator being restored by suitable adjustment of the attenuator, associated therewith.

APPENDIX I.

NOTES ON WORKING STANDARDS EMPLOYING CARBON TRANSMITTERS ("SETAC").

(*See* the text of these notes on pp. 73-107 of the "Livre Jaune"; pp. 40-55 of the English Translation. Addendum No. 3 to Appendix I on p. 108 of the "Livre Jaune"; p. 59 of the English Translation to be replaced by the following text):—

ADDENDUM No. 3 to APPENDIX I.

DEFINITION OF THE NORMAL CALLING INTENSITY TO BE USED IN PHONOMETRIC TESTS.

The "normal calling intensity for tests" is defined by means of the distortionless "SFERT" and the volume indicator, associated therewith.

The volume indicator, which is an integral part of the "SFERT" is adjusted in the following manner: the grid bias is regulated so that a deflection of two divisions is obtained when no acoustic energy agitates the transmitter; the gain control key is moved to position M and the gain control potentiometer is set to position 8.

The transmitter system of the "SFERT" having been set for normal operation, the volume indicator is shunted across the said system. It is then considered that the operator, speaking into the condenser microphone and uttering a typical phrase, is doing so with a normal calling intensity if the maximum needle deflections on the volume indicator are equal to about 30 divisions once every three seconds. Below are listed some typical phrases, selected so as to contain each of the principal vowel sounds:—

One, two, three, four, five.

Eins, zwo, drei, vier, fünf, sechs, sieben, acht, neun, zehn.

Joe took father's shoe bench out.

She was waiting at my lawn.

Paris, Bordeaux, Le Mans, Saint-Leu, Léon, Loudun.

This normal calling intensity should be preserved throughout all tests.

Numerous measurements have shown that it corresponds to the average calling intensity used in an ordinary telephone conversation.

This "normal calling intensity for tests" is about 16 decibels below the reference volume (*see* the C.C.I. recommendation entitled: "Characteristics, recommended for peak indicators").

APPENDIX II.

NOTE ON WORKING STANDARD SYSTEMS USING ELECTRO-MAGNETIC TRANSMITTERS ("SETEM").

(*See* the text on this note in the "Livre Jaune," pp. 109-122 (English edition, pp. 59-70) which has not been modified.)

INTERNATIONAL METHOD FOR MEASURING ARTICULATION.*

The International Consultative Committee—

Considering the results of the comparative tests for articulation in various languages, carried out by the "SFERT" (see Appendix D, "Livre Jaune," p. 235—English edition, p. 121—entitled: "Comparative articulation tests in various languages").

Unanimously advises:—

That the guiding principles outlined below should be followed in tests for articulation:—

(*a*) *Logatomes to be used.*—In order to avoid the inconvenience resulting from the use of a restricted number of logatomes, recorded on systematic lists, established once and for all (after a time the operators memorise certain sequences of logatomes), it is desirable to create a very large collection of logatomes.

For the sake of simplicity and international standardisation it is desirable to use logatomes, made up from consonant-vowel-consonant as well as "consonance"-vowel-"consonance." ("Consonance" signifies a group of two or three consonants, which when used in a logatome are pronounced as a single vocal sound). On the basis of the various sounds which make up Esperanto, which contains the sounds most frequently occurring in all of the spoken languages, excluding those which cannot easily be pronounced by everybody, a collection of Esperanto logatomes has been made up (Appendix A).

With the aid of the small pamphlets, entitled: Clé de l'esperanto, Esperanto Key, Esperanto Schlüssel, etc., it should be a simple matter for any Administration or Operating Company to transcribe the Esperanto logatomes into the language of its own country (the spelling being in accordance with the usage of its natives). It is recommended that the Esperanto spelling be preserved on the test cards and the rules of pronunciation of that language be observed.

(*b*) *Operating Method.*—The logatomes should be read, successively, over the testing system by the operator, who should speak in a uniform tone of voice, at the voice intensity used in telephonometric tests; he should speak distinctly and without exaggerated articulation[1] at a definite speed, for example, one logatome in three seconds.[2]

The listening operator or operators record the logatomes as they understand them at the receiving end of the system.

When the reading and recording are completed a comparison is made between the logatomes transmitted and received, and a record is made of the proportion of correctly received logatomes. This comparison should preferably be made by some person who has not taken part in the test.

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* This text replaces the one under the same title which appears on pages 123-209 of the *Livre Jaune* (English Edition, pp. 68-121).

(1) The pronunciation of the various vowels is indicated in the following table:—

	German	*English*	*French*
a	Saal	bar	Mare
e	beere	late	fée
i	liebe	meet	pie
o	sohle	note	faute
u	schule	school	four

(2) Another method of enunciating logatomes, already in use by several Administrations, consists of incorporating them in a conventional phrase.

Several variations of this method may be used :—

1. For example, instead of using a collection of logatomes (card system) a logatome printing machine, operating on the following principle, may be used. This machine has three wheels ; the two outside wheels carry printer's types of consonants or " consonances " in Esperanto, the middle wheel similarly types of vowels. The three wheels are set at random, and a key is depressed which causes a logatome to be printed. In this manner a list of logatomes is obtained and this list is used only once.

2. Another modification of the above method is that used in March, 1930, for tests made by the " SFERT " Laboratory.

Lists of 50 logatomes are made up on the following principle :—

(*a*) A given initial, middle or final sound recurs the same number of times in each list.

(*b*) The 41 initial sounds, the 5 middle and the 21 final sounds, which go to make up the 4300 Esperanto logatomes contained in Appendix A, are made up to 50 in the following manner :—

the 41 initial sounds are augmented by : b, l, m, n, r, s, ŝ, t, v.
the 5 middle sounds are repeated 10 times.
the 21 final sounds are repeated twice and augmented by : l, m, n, r, s, ŝ, t, v.

The added sounds are chosen because they occur most frequently in the language.

From three boxes 50 initial, 50 middle and 50 final sounds are selected and a list of 50 logatomes is prepared by writing down the logatomes thus obtained in an arbitrary sequence. In this manner a large number of different lists may be obtained. The number of logatomes is always 4300, but the probability is very small that, in the various groups, the same 50 logatomes in the same sequences are drawn. If one has access to a large number of lists (say 300), each containing 50 logatomes, there is but a remote chance that the operators will remember a certain sequence of logatomes. The drawing of logatomes by chance, although it takes considerable time, is an advantageous if not economical way of establishing a collection of lists.

Instead of recording the logatomes in columns on one list, they may be entered, individually, one per card. Fifty cards constitute a " pack of logatomes " ; and any number of packs may be prepared. When a test is to be made, the cards are shuffled in any one pack and the logatomes are read out in the arbitrary sequence produced.

3. The logatomes may be recorded on individual cards, each card containing but one logatome. When a test is to be made, cards are drawn at random from a pack. The cards as drawn are then placed in a suitable container. The talking operator picks up the cards in sequence, reads out the logatomes and places the cards in another container in the order of reading.

General Remarks. Considering that the test results depend not only on the listening but also on the talking operator, it is desirable to interchange these operators (for example, in rotation). Furthermore, the number of operators should not be less than three.

Since, on the other hand, it is tiring to listen and record more than 100 consecutive logatomes, it is recommended that each individual test should comprise a definite number of logatomes, not exceeding 100. A complete test should, however, contemplate the recording of a sufficient number of logatomes. It has been found that, in order to obtain a mean variation of less than $\pm$ 2 per cent. more than 1500 logatomes should be received and recorded.

Make-up of testing teams and comparison of results obtained by such teams.—It is essential that the operators in a team engaged on articulation tests should produce uniform results. Any operator who repeatedly tends to show irregular or abnormal results should be eliminated.

Experimental practice co-efficient.—It is well known that various testing teams are influenced in their results by the amount of training they have had and by their physical condition. In order to obtain comparable results, it is therefore necessary to make a correction by applying an experimental practice co-efficient.

It is essential to state whether published results are corrected or not by the application of the experimental practice co-efficient. Also, in order to compare the results of different tests, the data should always be accompanied by a precise indication of the number of logatomes received.

It is essential that the reference equivalent of the circuit, over which the articulation test is made should be given in the report of the test.

Regarding methods to be used in correcting the results of articulation tests in order to allow for experimental co-efficient of the testing crew, the C.C.I. cannot for the present make a final recommendation.

Nevertheless, since it is necessary to correlate, as soon as possible, the results obtained with more or less experienced crews of different nationalities, it is even now desirable and practicable to recommend a tentative method of correction.

Two methods have been suggested as temporary expedients: one of them is described in Appendices B_1 and B_4 and the other in Appendix C, below.

Although the experience gained up till now is not as great as one might wish, it is nevertheless a fact that the results obtained with various crews, using the first correction method, do not differ greatly from one another. On the other hand, the second method of correction is in common use in the United States of America.

The C.C.I. therefore recommends that, provisionally, the results of articulation tests shall be corrected, as far as possible, in accordance with the methods described in Appendices B_1 and B_2 and shall be expressed in terms of the *ideal sound articulation.*

Note.—In cases where it is only necessary to determine the effect on articulation of a small change in one variable of a system, it is sufficient to ascertain the difference between the articulation measured before and after the change of the variable, indicating however that the figure obtained is *the uncorrected difference in articulation for logatomes.*

APPENDIX A.

ESTABLISHING A COLLECTION OF LOGATOMES.

The system described below, concerning the make-up and formation of logatomes for international articulation tests, has been adopted by the C.C.I.

1. The Esperanto alphabet has been taken as a basis by reason of the great phonetic simplicity of that language. Publications (known as Keys), explaining the rules of pronunciation of Esperanto, are available in most languages of the world.

2. Each logatome is made up of the following arrangement: " Consonance "-Vowel-" Consonance."

By " Consonance " is meant either a single consonant or a group of consonants, always provided that the logatome formed can be pronounced as a single vocal sound.

3. " Consonances," which have been found too difficult to pronounce by the German, English or French testing teams, have been eliminated.

4. The table given below has been drawn up in accordance with the system adopted.

The first column contains the " consonances " (consonants or groups thereof) which form the first part of a logatome.

The second column contains the vowels (Esperanto has no diphthongs).

The third column contains the "consonances" (consonant or groups thereof) which form the third part of a logatome.

Experts on Esperanto are of the opinion that the groups of consonants can easily be pronounced in accordance with Esperanto phonetics.

The combination of the various elements, contained in the table, permits the creation of 4300 logatomes. This number would seem sufficiently great for the needs of articulation tests, and it allows for the elimination of logatomes which might prove abnormal for pronunciation in certain languages.

As an example, three lists of 50 logatomes each out of the 4300 logatomes are given below.

Table of Consonants (or Consonances) and Vowels used as the basis of Logatomes in Esperanto for International Articulation Tests.

Initial Consonances.	*Intermediate Vowels.*	*Final Consonances.*
B	A	B
BL	E	C
BR	I	Ĉ
C	O	D
Ĉ	U	F
D		FT
DR		G
F		K
FL		L
FR		M
Ĝ		N
G		NG
GL		P
GR		R
H		RS
J		S
K		ST
KL		Ŝ
KR		T
L		V
M		Z
N		
P		
PL		
PR		
PS		
R		
S		
SL		
SP		
ST		
STR		
Ŝ		
ŜL		
ŜR		
ŜT		
T		
TR		
V		
VL		
Z		

Note.—The above consonances and vowels are written in Esperanto.

Examples of Lists of Logatomes for International Articulation Tests.

List No. 1.

GUV	FRIZ	PROR	SLAD	TOM
ŜUT	KRENG	NID	SEK	PLEL
GLUP	PIV	DREŜ	ĈEST	ŜLIŜ
MAG	KLAFT	SEP	STUC	RUST
VOFT	TRARS	HUZ	ŜTON	ZEG
DONG	GRUS	VAL	NOR	TUM
BEV	VLARS	BIN	BLAT	LIĈ
BROT	SPIL	LIS	ĜIB	FLIN
MOŜ	JOF	RUF	KEB	PSOR
STRAM	ŜAK	ŜREC	CAS	FUĈ

List No. 2.

ĜEV	FOS	HER	SEC	KAP
STUST	BEFT	PREM	TRAŜ	COT
VLEM	MOG	BLAFT	ŜUF	TEL
STRARS	VAN	REĈ	GOD	TUN
FLIZ	ŜUF	ŜRUV	JUT	MAST
ŜTONG	DRING	RIR	BRIB	ŜLEM
PLAV	KLAS	ĈAT	LEB	VIR
ZAL	LOK	SID	SPUŜ	NIZ
NUG	PSOĈ	SLIRS	FRIS	BIP
DUL	GLUN	KROK	GROŜ	POC

List No. 3.

KAM	REF	NIST	TRIV	RED
DAK	SAŜ	SPOZ	LON	NIS
TET	KLIĈ	CEN	ZARS	VOL
STEL	GLIŜ	BROG	LOK	MOM
ŜIF	PRUV	FAL	SOZ	ŜTES
KRIFT	ŜLUP	ŜRUC	BLAŜ	PSUS
ĜEB	PLUD	TAĈ	FLOB	BUG
GUT	GRING	PUFT	MAST	FROC
VLON	HIP	JER	ŜAV	VURS
STRER	ĈUR	BEM	SLING	DRAT

APPENDIX B_1.

CALCULATION OF THE IDEAL ARTICULATION OF LOGATOMES AND THE IDEAL ARTICULATION OF SOUNDS.

Definitions.

The logatome articulation L is the percentage number of logatomes, correctly received over a given circuit by a given testing crew.

The sound articulation D is the percentage number of individual speech sounds, correctly received over a given circuit by a given testing crew.

Each Esperanto logatome, recommended by the C.C.I., is considered as comprising three individual speech sounds, a consonant (or group of consonants), a vowel and a consonant (or group of consonants).

The *ideal logatome articulation* L_i and the *ideal sound articulation* D_i are the corresponding values to articulation, obtained over a given circuit by an ideal testing crew.

The band articulation B is the percentage number of characteristic bands of speech, correctly received over a given circuit by a given testing crew.

The *ideal band articulation* B_i is the corresponding value of band articulation obtained over a given circuit by an ideal testing crew.

The relation between B and B_i is $B = ZB_i$, where Z is the crew factor (co-efficient de pratique de l'équipe—Kennziffer des Messtrupps). The value of Z is different for different crews at a given time and it is also different for the same crew at various times. Z would be unity for an ideal crew.

The mean daily value of Z increases for the same crew as the latter becomes more expert.

The relation between B and D is given by the formula :—

$$D = \sum \frac{100\, k_l}{1 + a_l\left[\left(\frac{100}{B}\right)^l - 1\right]}$$

where k_l and a_l are constants for a common value of the index l, which corresponds to the number of characteristic bands in a sound.

The relation between B_i and D_i is the same as between B and D.

The figures in the table below may be plotted in curve form to show, graphically, the above relations between B and D (or the relation between B_i and D_i) :—

$\frac{B}{100}$	$\frac{D}{100}$
0	0
0·1	0·215
0·2	0·450
0·3	0·660
0·4	0·795
0·5	0·870
0·6	0·915
0·7	0·950
0·8	0·975
0·9	0·987
1·0	1·0

In order to obtain the value of the ideal sound articulation for a given circuit, for which a value of the sound articulation has been measured by a given crew, the following method is used :—

(1) The crew measures the articulation of the crew calibration circuit, for which B_i is known. B_i for the selected circuit (a distortionless reference system with a low-pass filter, transmitting up to 1900 p : s, conforming to the curves shown in Figs. 1 and 1A in the Appendices hereto) is 0.64.

Let D' be the value of the sound articulation, measured on the calibration circuit.

(2) By means of the curve just referred to the value B' of the band articulation, corresponding to D', is obtained.

(3) Dividing B' by B_i (the ideal band articulation of the calibration circuit) gives the crew factor Z of the crew.

It is preferable, in order to obtain the crew factor Z, to plot as a function of time the mean curve of the variations of articulation obtained successively by the crew using the calibration circuit. This curve will then give the crew factor, at any time, in a more exact manner than will a reference to a particular reading of the crew at a given time of the day.

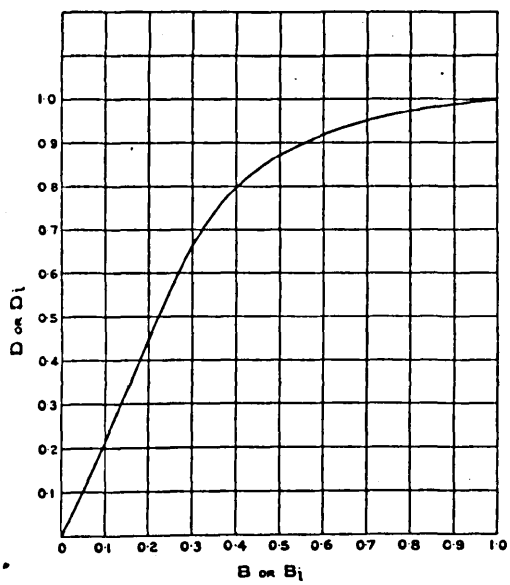
(4) Let D'' be the value of the sound articulation, measured by the same crew on a given circuit, for which it is desired to calculate the ideal sound articulation or the ideal logatome articulation.

(5) The curve gives the value of the band articulation B'', corresponding to the sound articulation D''.

(6) Dividing B'' by Z gives the ideal band articulation B''_i, corresponding to B''.

(7) The value of D''_i, corresponding to B''_i, will be found on the same curve.

D''_i is the ideal sound articulation, corresponding to the value D'' of sound articulation, measured on the circuit under consideration.



C.C.I. LOGATOMES IN ESPERANTO.

In order to obtain the value of the ideal logatome articulation the calculation of the sound articulation is made as indicated above; the ideal logatome articulation is then obtained from the following general expression:—

$$L_i = 100\left(\frac{D_i}{100}\right)^3$$

since there are three sounds per logatome.

For more complete information on the subject see Appendix B_3, entitled: "Calibration of Articulation Testing Crews."

Appendix referring to Fig. 1 and Fig. 1a.

The low-pass filter with a nominal cut-off of 1500 p:s serves to calibrate the articulation crew from the point of view of their degree of training. The attenuation and the characteristic impedance of the filter as functions of the frequency are shown in Fig. 1 and Fig. 1A. The circuit diagram of the filter is as shown on page 49.

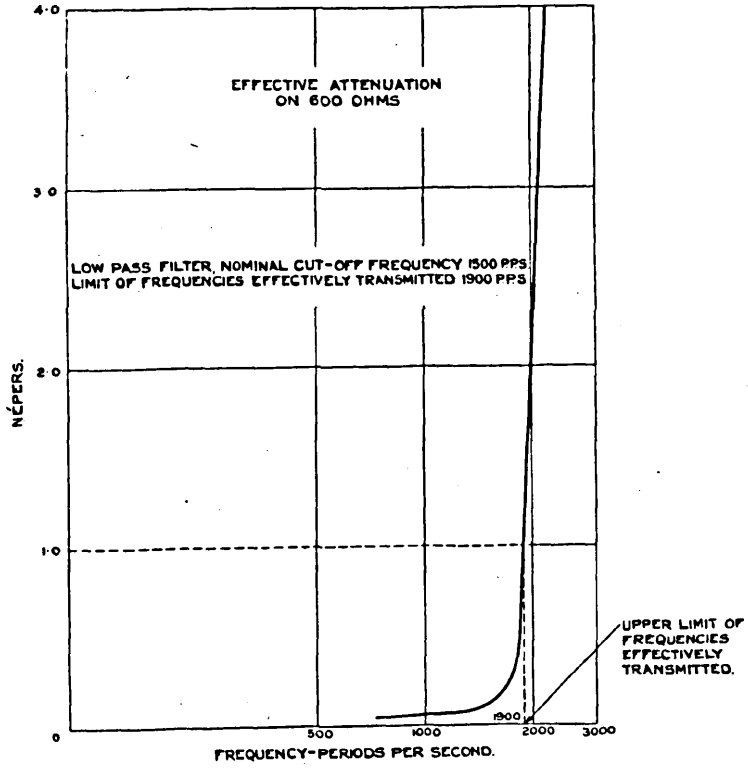


FIG. 1.

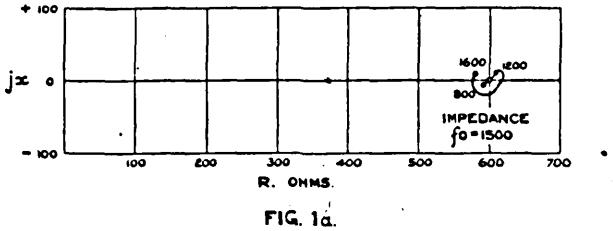
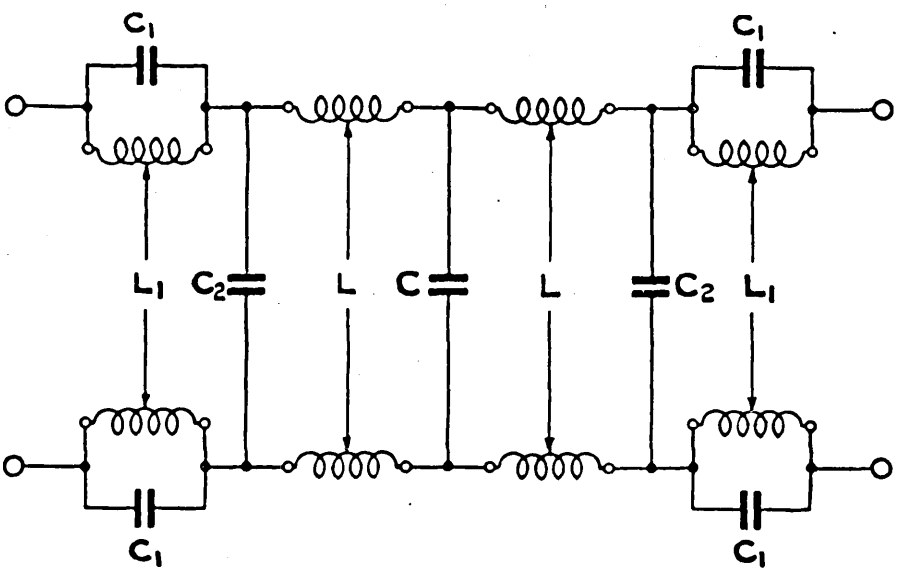


FIG. 1a.



SCHEMATIC ARRANGEMENT.

The inductance coils L_1, L, L and L_1 are wound in two halves on the same core. The values of the inductances and capacitances C, C_1 and C_2 are as follows :—

L = 0.050 H	C = 0.285 μF
L_1 = 0.0158 H	C_1 = 0.287 μF
	C_2 = 0.230 μF

The time constants of the inductance coils L/R (ratio of inductance to effective resistance), with about one volt across the terminals and the frequencies indicated are :—

200 p : s ...	0.0116
800 „ ...	0.0106
2000 „ ...	0.0092

The time constants of the condensers (or, rather the product : 2π f CR) at the frequencies 50, 800 and 7000 are :—

Frequency f	2π f CR
50 p : s ...	0.009
800 „ ...	0.012
7000 „ ...	0.017

The inductance coils are toroidal in form, wound on compressed iron rings, 40 mm internal diameter, 60 mm external diameter and 200 mm² cross-section. The windings are of double-cotton covered copper wire, particulars of which are given below :—

Inductance.	*Number of turns.*	*Diameter of wire.*
L	Approx. 2 × 850 turns	0.5 mm
L_1	„ 2 × 450 „	0.7 mm

The windings are so disposed and balanced that each winding has an inductance of $L/2$, $L_1/2$ respectively.

The condensers are of the ordinary paper-insulated type.

APPENDIX B_2.

CALIBRATION OF ARTICULATION TESTING CREWS.

1. General.

The values which will be obtained by a testing crew, engaged on articulation measurements on a given telephone circuit, will to a certain extent depend on the previous training of the crew as well as on the intellectual development of the various operators in the crew. Different crews will therefore obtain different articulation values on a given circuit and the same crew may obtain different results at various times. For example, one crew obtained a value of 65 per cent. for articulation on a certain telephone circuit when it first started on its career. After that crew had been in training about six weeks, the value obtained by it on the same circuit increased to 75 per cent. This makes it very difficult to establish comparable relations between articulation values, obtained under different circumstances or by different testing crews. In order to overcome this difficulty it is necessary to develop some method of calibrating an articulation testing crew.

In an article, entitled : " The calculation of the articulation of a telephone circuit from the constants of the circuit," a French translation of which appears on pp. 153 to 194 of the " Livre Jaune"—English Edition, pages 83 to 111 (C.C.I. Proceedings, Plenary Meeting, 1930), Dr. Collard gives details of such a method of calibrating an articulation testing crew. The method described in that article is based on the use of test syllables, in which the individual speech sounds occur with the same frequency as in English as ordinarily spoken. In Esperanto, from which the C.C.I. has taken the logatomes to be used in international tests of articulation (*see* Appendix A above), all sounds, difficult to pronounce, have been eliminated. Whilst the basic principle of the calibration method described by the author also applies to the C.C.I. Esperanto logatomes, the curve on which the application of the method depends is different from that given in the above-mentioned article.

The object of these notes is to give a short résumé of the calibration method as well as some detailed information relative to the new curve, which should be used in order to make the method applicable to the C.C.I. Esperanto logatomes (*see* curve in Appendix B_1 above).

2. Theory of Calibration Method.

While each sound contains frequency components, ranging over the greater part of the audible frequency band, the principal components which enable the sound to be recognised are all grouped together in one or more narrow frequency bands. Some sounds have only one of these bands, whilst others may have as many as five. Since it is by observing the frequencies at which these bands occur that a listener recognises a sound, they are known as the " characteristic bands of the sound." We can imagine the listener receiving the various characteristic bands in a sound, considering them in turn, recognising the frequency at which each one occurs and deciding which is the sound emitted. The probability of the listener's observing a sound correctly thus depends essentially on the probability of his recognising correctly the individual characteristic bands. The latter probability is known as the band articulation.

It can be shown that, if D represents the average sound articulation and B the average band articulation, the following relation exists between them :—

$$D = \sum \frac{100 k_l}{1 + c_l \left[\left(\frac{100}{B} \right)^l - 1 \right]}$$

where l is the number of characteristic sound bands and c_l and k_l are constants. For further detailed information on this formula and the method of determining the constants the reader is referred to the above-mentioned article.

The values of the constants applying to the C.C.I. Esperanto logatome list have been calculated,

the table of numerical values and the curve in Appendix B_1 above giving the relation between the sound articulation and the band articulation.

3. Applications of the Calibration Method.

When a sound is transmitted to a listener there are two factors which determine whether or no the latter will recognise a given characteristic band. The first of these factors depends on the characteristics of the circuit over which the sound is transmitted; if, for example, the circuit has great distortion the listener will have great difficulty in recognising the characteristic band. The second factor depends upon the individuality of the listener, who, if he is a slow thinker or is incapable of concentrating his attention, will have difficulty in recognising a characteristic band. It is the second factor which improves as the operator becomes more skilled. If we assume an ideal observer, that is to say, one for whom the second factor is unity and if we determine the mean probability of his receiving correctly a characteristic band over a given circuit, we shall obtain a value which we may denote as B_i. If, on the other hand, we assume a non-skilled operator and if we determine the probability of his receiving correctly a characteristic band over an ideal circuit, *i.e.*, a circuit for which the first factor is unity, we obtain a value which we may call Z. If we now take the given observer and let him listen on the given circuit, the probability that he will correctly receive a characteristic band will be the product of the two preceding probabilities, that is to say, $Z\ B_i$. The average band articulation therefore depends on two distinct factors. The first, Z, is entirely dependent on the crew factor, whilst the second, B_i, depends entirely on the characteristics of the circuit. If we use two different articulation testing crews on a given circuit, the value of Z will be different for the two crews, whilst B_i will be the same.

In order to obtain an articulation value which is independent of the crew and which therefore will be a true criterion of the functioning of the circuit, it has been suggested that a term "ideal sound articulation" should be introduced. The value of this articulation is that which will be measured on a given circuit by an ideal crew (for which Z is unity). The value of the ideal sound articulation can be calculated from the test results obtained by a certain crew, using the C.C.I. Esperanto logatomes according to the method outlined in Appendix B_1 above.

Dr. Collard has shown, in the article cited, how B_i may be calculated for any given circuit. For example, it has been found that for the "SFERT" with distortion $B_i=0.46$. That circuit could be used to calibrate a crew.

It must be remembered that the value of the articulation is a measure of the ability of a telephone circuit to transmit a conversation. Since the fundamental frequency of a female voice is considerably higher than that of a male voice, it follows that a given circuit may transmit the male voice better than the female voice, or *vice versa*. Each circuit will therefore have two band articulation values, one male and one female. The value given above for the "SFERT" is that for a male crew.

4. Conclusions.

It is well known that the value of the articulation, measured by a given crew, depends very largely on the training and individuality of the crew. Each measured value of articulation is therefore influenced not only by the characteristics of the circuit, but also by those of the crew. In order to avoid this difficulty it is proposed to use a value which may be termed "the ideal sound articulation," this value being defined as the articulation value obtained by an ideal crew. Since this value is a function of the circuit alone, it is a true criterion of the circuit characteristics. By the use of the method described it is possible to calibrate an articulation crew and thus it is possible to determine the ideal sound articulation, corresponding to any measured value of sound articulation. The values of the ideal sound articulation obtained by different crews are directly comparable and it is therefore suggested that all measured values of articulation should be transformed into the corresponding values of ideal sound articulation before they are published.

APPENDIX C.

METHOD USED IN THE UNITED STATES TO CORRECT THE RESULTS OF ARTICULATION TESTS IN ORDER TO ALLOW FOR THE CREW FACTOR OF THE OPERATORS.

The following method is used by the American Telephone and Telegraph Company to correct and compare results of articulation tests :—

Let L (in the case of logatomes) and D (in case of sounds) denote the articulation, measured by a crew on the " test circuit " at any given time.

Let L' (in the case of logatomes) and D' (in case of sounds) denote the articulation measured by the same crew on the " reference circuit " at the same time.

Let L_o' (in the case of logatomes) and D_o' (in case of sounds) be the articulation values for the same reference circuit, chosen as reference values. L_o' and D_o' are deduced from representative and consistent results obtained from measurements made by competent and well-trained crews.

On the curves shown in Fig. 2 the position of a point (abscissa : L' or D' and ordinate L_o' or D_o') determines the value of x for the crew and for the test in question. The aforementioned curve in the value of x gives for an abscissa L (or D) the corrected value L_o (or D_o) for the articulation of the circuit tested.

In order that the correction may be accurate, it is important that the verification test on the reference circuit should be made under conditions exactly comparable to those of the test circuit and also that the reference circuit should have characteristics, which do not differ greatly from those of the test circuit. For this reason it is important to have available a certain number of reference circuits of different characteristics, so that one or more of these reference circuits may be chosen for verification tests in any given case.

It is necessary to have additional information in order to determine the " reference values " of the articulation, corresponding to the various reference circuits when Esperanto logatomes are being used.

In carrying out articulation tests it is of course essential that the instructions regarding these tests are followed in detail if comparable results are to be obtained.

The curves, referred to above, have been drawn to a minimum value of $x = 0.70$. If smaller values than that are obtained it is an indication that the test results cannot be compared with any degree of precision with the " reference values," because of insufficient experience of the crew or other reasons.

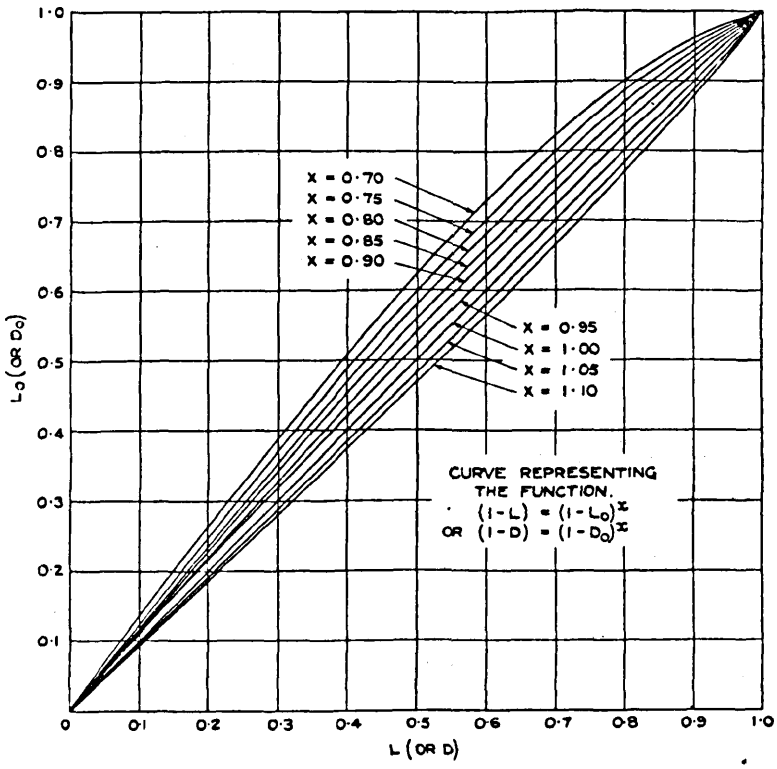


TABLE OF VALUES OF ABSCISSAE L (OR D) CORRESPONDING TO DIFFERENT VALUES OF ORDINATES L_0 (OR D_0) AND TO DIFFERENT VALUES OF INDEX X.

VALUES OF L_0 (OR D_0)	VALUES OF L (OR D) FOR X =								
	0·70	0·75	0·80	0·85	0·90	0·95	1·00	1·05	1·10
0·2	0·15	0·16	0·165	0·17	0·18	0·18	0·20	0·205	1·217
0·4	0·31	0·325	0·34	0·355	0·37	0·38	0·40	0·415	0·425
0·5	0·39	0·41	0·425	0·445	0·46	0·485	0·50	0·515	0·535
0·7	0·57	0·60	0·62	0·64	0·66	0·68	0·70	0·72	0·735
0·9	0·80	0·82	0·84	0·855	0·875	0·888	0·90	0·91	0·92

FIG. 2

GRAPHIC SYMBOLS TO BE USED IN TELEPHONY.*

The International Consultative Committee—

Unanimously advises :—

That the Graphic Symbols to be used in telephony, proposed by the Commission which met in Berne in April, 1928, and later by the Plenary Meeting of the C.C.I. in Paris (June, 1928) and afterwards confirmed by the International Electrotechnical Commission at Stockholm in July, 1930, and published as Document No. 42 of that Commission under the title: "International Symbols—Part 3—Graphic Signs for weak current installations," should be adopted by all Telephone Administrations and Operating Companies and that they request their contractors of telephone material to do likewise.

* This text replaces the one under the same title which appears on p. 234 of the *Livre Jaune* (English Edition, p. 134).

(A.a.2.) Recommendations of Principle.*

Effective Transmission Equivalent.

The International Consultative Committee—

Considering :—

(1) That the object of telephonic transmission over a whole circuit, or part thereof, is to give easy communication without frequent repetition and without exacting a continuous effort on the part of the subscribers.

(2) That certain fundamental characteristics affect the ease with which conversations can be exchanged.

The more important characteristics referred to are given in a tabulated synopsis on page 55 (Annex 1), in which the relations between the characteristics are also shown.

(3) That, in order to obtain good quality transmission, it is necessary to impose suitable limits upon the combined effect of these important characteristics.

(4) That, furthermore, in order to compare the quality of transmission in various circuits, it is desirable to find a means of quantitatively expressing (in comparable units) the extent to which the various characteristics, in various degrees, affect the transmission as well as the combined effect of various combinations of these characteristics.

(5) That, in order to obtain this result, it is above all necessary to reach an international agreement concerning the definitions and methods of quantitative measurements in definite units, taking into account each characteristic in each particular case.

Unanimously advises :—

(1) That, in a telephonic communication, the quality of transmission, being dependent upon the combined effect of all of the characteristics referred to, should be defined by the effective transmission equivalent of the telephonic communication considered.

(2) That the Memorandum below, entitled : " Definitions and methods of measurement proposed for the various electrical characteristics, affecting the quality of transmission of a telephone communication " shall be the basis of the study of this question.

MEMORANDUM.

Definitions and Methods of Measurement proposed for the various electrical characteristics affecting the quality of transmission of a telephone communication.

I. EFFECTIVE TRANSMISSION EQUIVALENT.

Proposed definition :—

The effective transmission equivalent of a telephone communication is the number of transmission units (nepers or decibels) which must be inserted in the " Modified Master Reference System " in order that the " Modified System " yields a telephone conversation equally satisfactory, from a general standpoint, to the communication considered, due regard being given to all the factors affecting transmission.

* This text replaces the one under the same title which appears on pp. 234-244 of the *Livre Jaune* (English Edition, pp. 134-140).

Method of measurement :—

The following method appears practicable for the measurement of the effective transmission equivalent of a given telephone communication :—

(*a*) A " Modified Master Reference System " is first to be defined, suitable to serve as a common basis of comparison for specifying and measuring the effective transmission. The detailed specification for this " Modified Master Reference System " has not as yet been drawn up. (On this subject, see the Minutes of the Final Session at the Plenary Meeting in Paris, 1931, Question 11, which has been assigned for study to the Fourth C.R., as well as Appendix 6 to the said Minutes.)

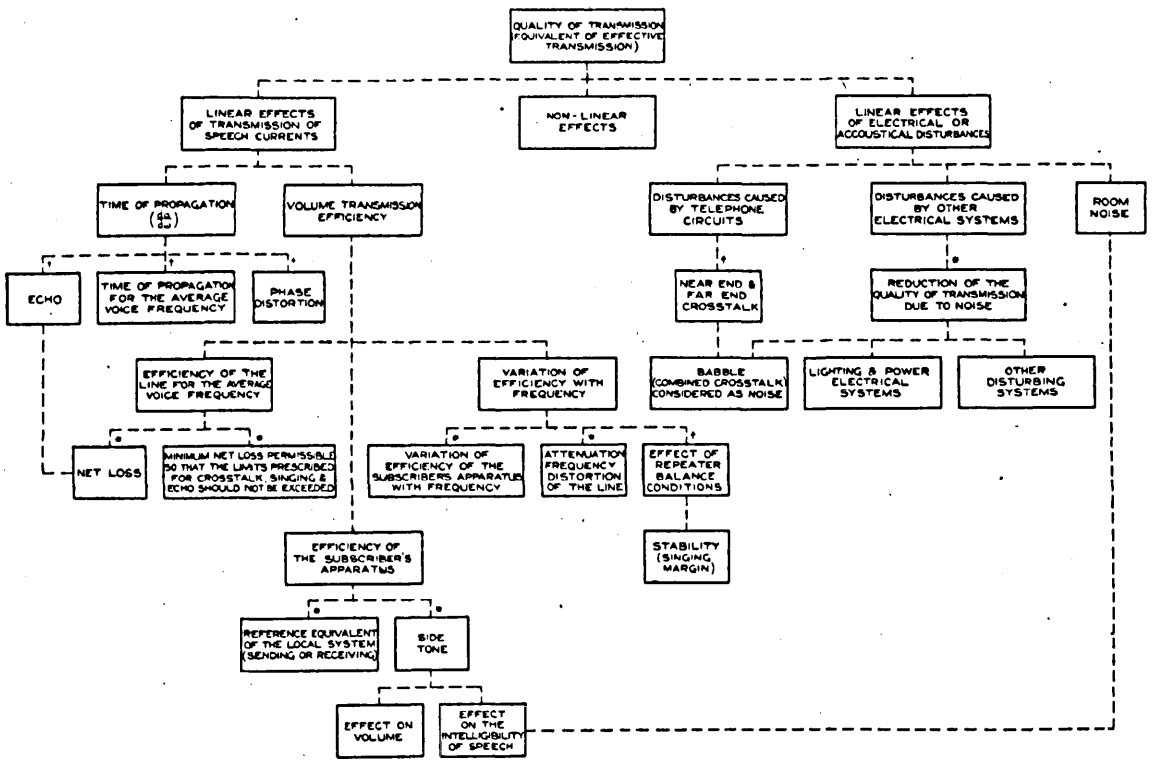
(*b*) A method of measuring the values relating to the quality of transmission on commercial telephone circuits under service conditions to be standardised.

(*c*) A relation to be established between the values of the quality of transmission under service conditions and the results of the laboratory measurements in order that the former values may be expressed in terms of the Modified Master Reference System.

Note.—For the present, and until the Modified Master Reference System is definitely specified, transmission data (based on effective transmission) are being gathered in the United States of America using a working standard system as a temporary reference.

ANNEX 1.

Table showing the relations between various electrical characteristics influencing the quality of electrical communication.


QUALITY OF TRANSMISSION (EQUIVALENT OF EFFECTIVE TRANSMISSION)
LINEAR EFFECTS OF TRANSMISSION OF SPEECH CURRENTS
NON-LINEAR EFFECTS
LINEAR EFFECTS OF ELECTRICAL OR ACCOUSTICAL DISTURBANCES
TIME OF PROPAGATION (dt/dω)
VOLUME TRANSMISSION EFFICIENCY
DISTURBANCES CAUSED BY TELEPHONE CIRCUITS
DISTURBANCES CAUSED BY OTHER ELECTRICAL SYSTEMS
ROOM NOISE
ECHO
TIME OF PROPAGATION FOR THE AVERAGE VOICE FREQUENCY
PHASE DISTORTION
NEAR END & FAR END CROSSTALK
REDUCTION OF THE QUALITY OF TRANSMISSION DUE TO NOISE
EFFICIENCY OF THE LINE FOR THE AVERAGE VOICE FREQUENCY
VARIATION OF EFFICIENCY WITH FREQUENCY
BABBLE (COMBINED CROSSTALK CONSIDERED AS NOISE)
LIGHTING & POWER ELECTRICAL SYSTEMS
OTHER DISTURBING SYSTEMS
NET LOSS
MINIMUM NET LOSS PERMISSIBLE SO THAT THE LIMITS PRESCRIBED FOR CROSSTALK, SINGING & ECHO SHOULD NOT BE EXCEEDED
VARIATION OF EFFICIENCY OF THE SUBSCRIBERS APPARATUS WITH FREQUENCY
ATTENUATION FREQUENCY DISTORTION OF THE LINE
EFFECT OF REPEATER BALANCE CONDITIONS
EFFICIENCY OF THE SUBSCRIBER'S APPARATUS
STABILITY (SINGING MARGIN)
REFERENCE EQUIVALENT OF THE LOCAL SYSTEM (SENDING OR RECEIVING)
SIDE TONE
EFFECT ON VOLUME
EFFECT ON THE INTELLIGIBILITY OF SPEECH

+ A PROVISIONAL LIMIT HAS ALREADY BEEN PRESCRIBED TO PREVENT EXCESSIVE EFFECTS ON THE QUALITY OF TRANSMISSION, BUT THIS LIMIT HAS NOT YET BEEN EXPRESSED AS A FUNCTION OF THE 'EFFECTIVE TRANSMISSION'.

• DATA HAS ALREADY BEEN GATHERED IN CERTAIN COUNTRIES, WHICH WILL PERMIT MEASUREMENT AS A FUNCTION OF THE 'EFFECTIVE TRANSMISSION'.

On long-distance circuits the effective transmission equivalents are, for the present, being obtained quantitatively by taking into account the following factors :—

(*a*) Net loss at 1000 p : s.
(*b*) Transmission impairment due to distortion.
(*c*) Transmission impairment due to noise.

II. NET LOSS AND TRANSDUCER LOSS.

Proposed definition :—

The net loss in a telephone circuit (excluding apparatus losses) or in a portion of a telephone circuit is the " transducer loss " measured under the conditions specified in each case.

The transducer loss of a telephone circuit or of a portion of a telephone circuit, terminating in two given impedances (generator and receiver) is equal to the ratio (expressed in transmission units) between the power delivered to the receiver over the circuit or portion thereof and the power which would be delivered to the receiver if the latter were connected to the generator through an ideal transducer.

An ideal transducer is a network which, when inserted between two impedances, transmits the maximum amount of energy from one impedance (generator) to the other (receiver). Such a network must annul the reactance in both directions and behave like an ideal transformer with an optimum transformation ratio.

Note.—It is interesting to compare the definition of the net loss with that of effective attenuation (see p. 18.)

Method of measurement :—

The net loss of an entire long-distance circuit or a part thereof can be measured with an ordinary transmission measuring set. The net loss may be positive (loss) or negative (gain). When stating the net loss of apparatus pertaining to a telephone circuit, it is necessary to give a complete account of the test conditions, such as terminating impedances, etc.

III. DISTORTION TRANSMISSION IMPAIRMENTS.

Proposed definition :—

The impairment in the quality of transmission due to distortion in a long-distance telephone circuit is the difference between the effective transmission equivalent of a typical, definitely specified communication comprising that circuit, and the effective transmission equivalent of an identical communication, except that the latter is distortionless.

Note.—The only type of distortion so far studied in its effect on the quality of the transmission is that due to variation of the net loss with frequency.

Method of measurement :—

The method of measuring impairment in the transmission due to a particular distortion is similar to that indicated in I (Effective transmission equivalent). In order to determine the impairment in the quality of transmission due to a restriction of the frequency band effectively transmitted (attenuation distortion) the quantitative measurements already made have been based on articulation tests and also on observations made under service conditions upon a large number of communications, using typical specimens of telephone sets.

III (a) TRANSMISSION FREQUENCY RANGE.

Proposed definition :—

The frequency band, effectively transmitted by a telephone circuit is the band, bounded by upper and lower frequencies at which the net loss exceeds by 10 decibels (1.15 népers) the net loss at 1000 p : s.

IV. NOISE TRANSMISSION IMPAIRMENTS.

Proposed definition :—

The impairment in the quality of transmission due to noise in a telephone circuit is the difference between the effective transmission equivalent of a typical, definitely specified communication, comprising that circuit and the effective transmission equivalent of an identical communication, disturbed by a line noise of specified nature and intensity.

Method of measurement :—

The method used to determine the impairment in the quality of transmission, due to a particular noise, is similar to that indicated in I (Effective transmission equivalent). In order to determine the impairment in the quality of transmission due to noise the quantitative measurements already made have been based on articulation tests and also on observations made under service conditions, of a large number of communications, using typical telephone sets (typical room noise included).

IV (a) NOISE.

Proposed definition :—

Noise is a sound of foreign origin in a telephone communication which tends to interfere with an easy and correct understanding of the conversation.

IV (b) LINE NOISE.

Proposed definition :—

Line noise is noise electrically transmitted by the telephone system and reaching the receiver, but excludes noise arising in or picked up by the microphone.

Method of measurement :—

Line noise is measured by means of the apparatus designed to measure noise objectively. This apparatus consists essentially of an amplifier, a suitable detector and a filter which " weights " the various frequency components in proportion to their disturbing influence upon telephonic transmission.

IV (c) ROOM NOISE.

Proposed definition :—

In telephony, room noise is the noise prevalent in that part of a room where the telephone apparatus is used.

Method of measurement :—

Room noise is measured by means of a noise meter of the direct-reading type, comprising a suitable filter and graduated in transmission units (decibels or népers). This instrument is described in Appendix VII to the Minutes of the final session of the Plenary Meeting in Paris, 1931, entitled : " A survey of room noise in telephone locations," by W. J. Williams and R. G. McCurdy (*see* page 331).

V. SIDE TONE.

Proposed definition :—

Side tone is the transmission and reproduction of sound by a local channel between the microphone and receiver in the same subscriber's set.

Method of measurement :—

Side tone is measured by the reference equivalent (expressed in terms of transmission units) of the local circuit through which the current flows, *i.e.*, between the microphone and the receiver in the same subscriber's set.

VI. VOLUME EQUIVALENT.

Proposed definition :—

The volume equivalent of a complete telephone communication is the number of transmission units (decibels or népers) which must be inserted in the Master Reference System in order that the latter and the communication under consideration may give the same acoustic impression in the receiver, the speech input power being the same in the two cases.

Note.—This definition is similar to that given above (*see* page 16).

Method of measurement :—

The volume equivalent of a complete telephone communication is measured by comparison with the European Master Reference System. The volume equivalent of a part of a system is measured by comparison with the corresponding part of the Master Reference System by a substitution method.

In order that such comparisons may be made under rigorously defined conditions and in order to simplify the testing method, it is proposed to adopt an " artificial voice " and an " artificial ear," which will be adopted as the normal methods for such comparisons.

VII. RETURN LOSS (4-pole passive network).

Proposed definition :—

The return loss in a telephone circuit is equal to the ratio (expressed in transmission units) between—

(1) The current at the sending end of the circuit, caused by waves reflected, either from a point where an impedance irregularity exists, or from the remote end of the circuit when a sinusoidal E.M.F. is applied to the sending end; and

(2) The current, which would be at the sending end if no irregularity existed in the circuit or at its termination, the generator at the sending end having an impedance such that there is no sending end reflection.

Note.—It is interesting to compare this definition with that of echo attenuation (see page 103).

Method of measurement :—

A return loss measuring set is used to measure the return loss in any circuit at any desired frequency.

VIII. RETURN LOSS (4-pole active network).

The reflection loss at a given point in a telephone circuit, equipped with repeaters, in normal operation, is called the active return loss at that point.

IX. SINGING MARGIN.

Proposed definition :—

The singing margin of a complete circuit is the minimum extra gain (at any frequency) which may be added in that amplifier which is nearest to a state of oscillation, without causing it to produce sustained or intermittent oscillations, all other conditions (such as temperature, the net loss, etc.) being rigorously defined.

Note.—It is interesting to compare this definition with that of stability (see page 94).

Method of Measurement :—

The singing margin of a long-distance telephone circuit is measured with the two ends of the circuit terminated by impedances which approximate the most severe practical conditions encountered

the gain being increased to the critical point, at which oscillation begins. The gain thus obtained, expressed in transmission units (decibels or népers) gives the desired value of the singing margin.

Note.—In order to determine the total singing margin in transit communications (*i.e.*, built-up circuits) the return loss is measured for the entire band of frequency effectively transmitted. This measurement is made from both ends of the long-distance circuit in the long-distance offices ; a transmission gain should be introduced at the transit centre, where the cord circuit repeaters or similar amplifying devices are available. The minimum value of the (active) return loss (at any frequency) thus determined, less half of the total normal gain in the two directions at the transit centre is in the majority of cases a sufficient approximation to one-half of the singing margin in a complete communication comprising the circuit under consideration.

X. ECHO.

Proposed definition :—

An echo is a wave which has been reflected at one or more points, where impedance irregularities exist (or reflected in any other way) with sufficient amplitude and delay to be recognised as a wave, distinct from that directly transmitted.

Method of measurement :—

It is not necessary to specify a standard method of measuring echo, since, at present, effective remedies are applied to keep the echo effect within certain limits before the circuit is put into use.

XI. CROSSTALK.

Crosstalk is defined as intelligible voice currents, observed in a receiver, connected to one telephone channel and arising from voice currents in a neighbouring telephone channel.

Near end crosstalk between channels, terminating at the same points, is the crosstalk which occurs at the end of the disturbed circuit, located near the source of the disturbing circuit. Far end crosstalk between circuits terminating at the same points is the crosstalk which occurs at the end of the disturbed circuit, remote from the source of the disturbing circuit.

XI (a) CROSSTALK VOLUME.

Proposed definition :—

Crosstalk volume is the intensity (expressed in transmission units, decibels or népers, related to a suitable reference level) of sound, occurring in a given transmission channel and produced by voice currents flowing in a neighbouring channel.

XI (b) CROSSTALK COUPLING.

Proposed definition :—

Crosstalk coupling is the transducer loss between a pair of terminals of one circuit and a pair of terminals of another circuit.

Note.—It is interesting to compare these definitions (XI, XI(a) and XI(b) with those given earlier in the text. (*See* page 17 under 7) and with those which follow (on pages 96 and 97).

Method of measurement :—

The measurement of crosstalk volume is done in a manner similar to that used for line noise, the disturbing circuit having current supply as under working conditions. Crosstalk coupling is measured with a crosstalk meter, graduated in transmission units (decibels or népers), the disturbing circuit being operated by the human voice or by a generator of suitable wave form.

XII. BABBLE.

Proposed definition :—

Babble is an unintelligible murmur, due to the combined effect of crosstalk arising from several sources. It appears as a form of line noise.

Method of measurement :—

Babble measurements are made in a similar manner to that used for line noise.

XIII. DELAY.

Proposed definition:—

Delay is to be understood as the time required for the speech waves to travel from one end of a circuit to the other. It is expressed, quantitatively, as $dB/d\omega$ (the envelope delay) where B is the phase displacement in radians and ω is 2π times the frequency in periods per second.

XIII (a) PHASE DISTORTION.

Proposed definition:—

Phase distortion occurs when the delay $dB/d\omega$ is not constant for all frequencies.

Method of measurement:—

It is not necessary, for the present, to specify a method of measuring phase distortion since it appears that the best practice is not to exceed certain limits when long-distance projects are being planned. It will, however, be desirable in the future to formulate exact methods of measuring delay and phase distortion.

XIV. NON-LINEAR DISTORTION.

Proposed definition:—

Non-linear distortion is the distortion which occurs in a telephone communication when the ratio between the voltage and the current is a function of the amplitude of either.

Method of measurement:—

The effect of non-linear distortion in a circuit (which manifests itself as a variation of the net loss as a function of the amplitude of the current) can be determined by measuring the net loss at the various frequencies of the transmitted band, various values of transmitted energy being used in the course of the measurements. The effect of non-linear distortion manifests itself in the form of harmonics, which are not present in the wave applied at the sending end. The value of the non-linear distortion is obtained by measuring the amplitude of these harmonics at the receiving end, when one or more sinusoidal waves are applied at the sending end. It will be desirable, in the future, to determine the effects of non-linear distortion, which can be measured and the methods which would be suitable for that purpose.

XV. MINIMUM NET LOSS.

Proposed definition:—

The minimum net loss in a circuit is the smallest loss, for which the circuit can be adjusted without exceeding the limits prescribed for the various factors which affect the transmission.

XVI. MINIMUM WORKING LOSS.

Proposed definition:—

The minimum working loss in a circuit is equal to the minimum net loss, plus a suitable tolerance or margin, with due regard to the variations of the circuit constants in relation to the nominal values as well as to maintenance conditions.

Uniform Value to be given to the Impedance of International Circuits.

The International Consultative Committee—

Considering:—

That, for various general reasons, it is desirable to maintain a uniform value of impedance for all international circuits measured from a repeater station, or from one of the terminal exchanges, by the adoption of suitable intermediate transformers.

That this impedance should be chosen in such a manner as to avoid, as far as possible, reflection losses at the ends of the long-distance circuits—*i.e.*, that its value should be as near as possible to that of the local circuits to which these long-distance circuits are generally connected.

That it has been found from tests carried out in various countries that the values of the impedance of local circuits vary appreciably with the frequency of the measuring current, with the length of the circuits and with the nature of the subscriber's apparatus.

That, in spite of the lack of precise information, it is possible to give, provisionally, to this impedance an average value sufficiently approximate for practical needs, and that, in many cases, satisfactory results have already been obtained.

That this choice (which, however, is subject to revision) will itself constitute an experimental basis for the future.

Unanimously advises:—

That the value to be given to the apparent impedance of international circuits (measured across the terminal transformers, and measured or calculated at a frequency of 800 periods per second) shall be provisionally fixed at 800 ohms; it may, however, fall within the limits of 600 and 950 ohms.

Combinations of International Circuits.

The International Consultative Committee:—

Unanimously advises:—

That for reasons of stability in transmission the combining of international telephone circuits shall never be made except between complete repeater sections (*i.e.*, at repeater stations).

Cut-Off Frequency and Attenuation of Repeater Sections on International Circuits.

The International Consultative Committee—

Considering:—

That it is sufficient to adhere to the maximum permissible limits for the levels on an international telephone circuit,

Unanimously advises:—

That there is no need to prescribe uniform limits for the attenuation of repeater sections.

Considering, on the other hand:—

That it is sufficient to prescribe the width of the frequency band effectively transmitted (frequencies at which the value of the equivalent does not exceed by 1.0 néper or 8.7 decibels, the value of the equivalent measured at 800 p : s. *See* Appendix B.d. 2, No. 4), and the maximum duration of transient phenomena,

Unanimously advises:—

That there is no need to prescribe a uniform value for the cut-off frequency on international circuits.

Practical Limits for the Reference Equivalent and Levels on an International Telephone Circuit.

The International Consultative Committee—

Unanimously advises :—

1. That the transmission (reference) equivalent of an international circuit, including the line transformers, tested at 800 p : s should not exceed 1.3 népers or 11.3 decibels for a 2-wire circuit and 1.1 népers or 9.6 decibels for a 4-wire circuit.

2. That it is desirable that efforts should be made to the effect that on circuits to be provided in the future the equivalent, tested at 800 p : s will not exceed the following values :—

1 néper or 8.7 decibels for 2-wire circuits;
0.8 néper or 6.95 decibels for 4-wire circuits;

whilst maintaining a sufficiently large value to satisfy the conditions laid down by the C.C.I. with respect to stability, crosstalk and noise.

3. That the variations of the equivalent with frequency and the levels of an international 4-wire circuit, as well as the corresponding variations with frequency of an international 2-wire circuit, should not exceed the limits prescribed in Appendix B.d. 2, No. 4, entitled : " Essential Clauses for a Typical Specification for the Supply of a Complete Telephone Cable between Terminal Offices."

Practical Limits for the Reference Equivalent of the National Sending and Receiving Systems in an International Communication between Two Subscribers.

The International Consultative Committee—

Recommends :—

(1) That, for an international connection between any two subscribers in the same continent, the reference equivalent of the national sending system should not exceed 2 népers or 17 decibels and the reference equivalent of the national receiving system should not exceed 1.3 népers or 11 decibels.

The " national sending system " includes the talking subscriber's set, and the chain of lines and exchange apparatus which connect the subscriber with the input terminals of the international circuit in the terminal exchange of the same country.

The " national receiving system " includes the listening subscriber's set and the chain of lines and exchange apparatus connecting the subscriber with the output terminals of the international circuit in the terminal exchange of the same country.

(2) That it is desirable, in future, when setting up new networks or when modifying existing networks, that an endeavour be made so that for about 90 per cent. of the subscribers the reference equivalent of the national sending system should not be greater than 1.7 népers or 15 decibels and the reference equivalent of the national receiving system be not greater than 1.2 nepers or 10 decibels.

Practical Limits of the Reference Equivalent of an International Communication between two Operators or between an Operator and a Subscriber.

The International Consultative Committee—

Recommends :—

(1) That the reference equivalent of an international communication between two operators or between an operator and a subscriber should not exceed the values given in the following tables :—

Communication between two Operators.		Communication between an Operator and a Subscriber.			
Reference equivalent of a connection between two operators.		Reference equivalent of a connection between an operator and a subscriber at the same end of an international line.		Reference equivalent of a connection between an operator and a subscriber at opposite ends of the international line.	
Subscriber's lines disconnected	Subscriber's lines connected	International circuit disconnected	International circuit connected	Subscriber's line disconnected	Subscriber's line connected
2·5 népers or 22 decibels	3·5 népers or 30 decibels	2 népers or 17 decibels	2·4 népers or 21 decibels	3·5 népers or 30 decibels	3·9 népers or 34 decibels

Note.—The above equivalents are based on a reference equivalent of the international circuit of 1·3 népers (or 11·3 decibels).

(2) That it is desirable in future, when setting up new networks or modifying existing networks, that an endeavour be made so that the reference equivalent of a connection between two operators or between an operator and a subscriber should not exceed the following values :—

Communication between Two Operators		Communication between an Operator and a Subscriber			
Reference equivalent of a connection between two operators		Reference equivalent of a connection between an operator and a subscriber at the same end of an international line.		Reference equivalent of a connection between an operator and a subscriber at opposite ends of an international line.	
Subscriber's lines disconnected	Subscriber's lines connected	International circuit disconnected	International circuit connected	Subscriber's line disconnected	Subscriber's line connected
1·8 népers or 16 decibels	2·8 népers or 24 decibels	1·7 népers or 15 decibels	2·1 népers or 19 decibels	2·9 népers or 25 decibels	3·3 népers or 29 decibels

Note I.—Various methods may be used by Administrations and Operating Companies to insure that the above limits of the reference equivalents are not exceeded. For example, various component circuits may be set up together for trial, representing the typical combinations of commercial subscriber's sets, subscriber's line circuits, junction circuits, toll and local office equipment. Each of these assemblages represents a complete national transmitter or receiver, which by means of telephonometric tests, may be compared with the distortionless Master Reference System or with a standard, calibrated against that System.

On the other hand, it may be sufficient to measure the reference equivalent of the subscriber's set under certain specified conditions and to measure or calculate the effective loss of the lines and equipment. From these data the reference equivalent of the national transmitter or receiver may be computed.

In any case, it is necessary to check the computed values by telephonometric measurements on the assembled circuits, representing the most typical national transmitting and receiving systems.

Note II.—Typical examples of the sub-division of maximum permissible reference equivalents for national transmitting and receiving systems are given in Appendices I, II, III and IV, hereinafter.

APPENDIX I.

SUB-DIVISION OF THE REFERENCE EQUIVALENT IN THE NATIONAL TRANSMITTING AND RECEIVING SYSTEMS OF THE GERMAN TELEPHONE ADMINISTRATION.

I. Organisation of the Long-distance Network of the German Telephone Administration.

In the German long-distance network the central long-distance offices, which handle such traffic, are divided into three classes. (*See* Addendum 1 to this Appendix.)

(1) *Distribution Centres.* (Endfernämter, abbreviated: EF), which are long-distance offices (not equipped with cord-circuit repeaters) associated with local offices (Ortsämter) in the same town and also connected to central offices in neighbouring areas, having no long-distance offices (Vermittlungsstelle ohne Fernamt, abbreviated: VStoF).

(2) *Transit Centres.* (Verteilfernämter, abbreviated: VF), which are long-distance offices (equipped with cord-circuit repeaters) which handle transit traffic for one group of distribution centres (EF).

(3) *Main Transit Centres.* (Durchgangsfernämter, abbreviated: DF), which are long-distance offices (equipped with cord-circuit repeaters) which handle the transit traffic for a group of transit centres (VF) to the corresponding distribution centres.

The main transit centres (DF) also handle directly the traffic of the distribution centres in their telephone area. Further, the main transit centres (DF) and the transit centres (VF) handle the long-distance traffic of the central offices associated with them as well as that of the offices in neighbouring areas, which have no long-distance offices (VStoF) but which are directly connected to the main centre. The main transit centres (DF) are located in the 15 most important central offices in Germany. The international circuits (with the exception of frontier circuits) terminate in the main transit centres.

A central office located in an area, in which there is no long-distance office (VStoF), is connected to the nearest long-distance office by means of toll-switching trunks (Fernvermittlungsleitungen) without an intermediary cord-circuit.

The long-distance circuits EF-VF (connecting a distribution centre with a transit centre) and VF-DF (connecting a transit centre with a main transit centre) are, generally, medium-loaded 2-wire cable circuits, not operated with repeaters, or also open wire lines, likewise without repeaters and their maximum loss is 1.3 népers. The long-distance circuits DF-DF (connecting main transit centres) are, generally, medium-heavy or extra light loaded 4-wire circuits and their maximum loss is 0.8 néper.

The setting-up of two long-distance circuits in a transit or main transit centre is carried out as follows:—

(*a*) If connection is desired between two 2-wire circuits or between a 2-wire and a 4-wire circuit, a cord-circuit repeater is inserted, the gain of which compensates for the loss of one of the circuits.

(*b*) If connection is desired between two 4-wire circuits, a device is inserted, which without giving rise to reflection, introduces a gain, equivalent to the loss, caused by one of the 4-wire circuits.

By these means the following results are obtained : *in all cases* the equivalent of the whole circuits, connecting any two long-distance offices (distribution centre, EF, transit centre, VF, or main transit centre, DF, is equal to that of a single circuit, that is to say, a maximum of 1.3 népers. Bearing in mind that the international circuits terminate in the main transit centres (DF) and that its connection to a national circuit is always made either through a cord-circuit repeater or else through a device introducing a transmission gain, the equivalent of a circuit between any German long-distance office and the terminals of an international circuit is practically equal to zero. This means that the long-distance circuits themselves do not enter into consideration from the point of view of the reference equivalent of the national transmitting and receiving system. In other words, in the network of the German Telephone Administration, the reference equivalent of the national transmitting (or receiving) system is equal to the reference equivalent of the local transmitting (or receiving) system.

II. Approximate Sub-division of the Reference Equivalent in the Local Transmitting and Receiving Systems.

The reference equivalents of the local transmitting and receiving systems (and therefore also for the national ones) break down into the following components :—

(1) The transmitting or receiving reference equivalent of the subscriber's instrument.

(2) The battery supply loss (transmitting).

(3) The effective attenuation in the subscriber's local line.

(4) The Central Office effective attenuation (which includes the effective attenuation of the current supply apparatus and various other losses).

(5) The effective attenuation in the Long-distance Office.

When the Central Office is not located in the same building as the Long-distance Office, the effective attenuation in the circuit, connecting the two offices, must also be included.

Addendum 2 to Appendix I gives the maximum values of attenuation in the various parts of the communication which are permitted in order that the maximum reference equivalents for the transmitting (or receiving) system, prescribed by the C.C.I. shall not be exceeded. It should be noted that in the transmitting as well as in the receiving system there is a tolerance of 0.2 néper to take care of the most unfavourable cases. The effective attenuation in the subscriber's local line, as given in Addendum 2, applies to a subscriber's circuit, about 5 km in length, made up of 2 km of 0.6 mm and 3.4 km of 0.8 mm cable conductors.

Under actual service conditions the maximum limit of the reference equivalent for the local transmitting (or receiving) system is only reached in rare instances, because :—

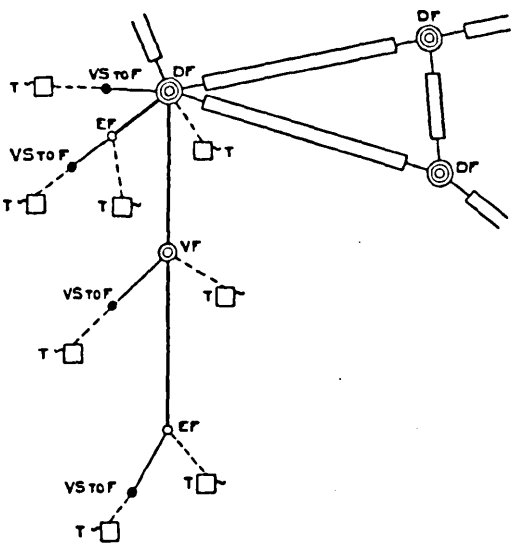
(*a*) Frequently, the subscriber's apparatus has a reference equivalent corresponding to, or even smaller than, the average reference equivalent of the " SFERT."

(*b*) Frequently, the subscriber's loops are less than 5 km and, therefore, not only is their effective attenuation smaller, but the battery supply loss is also less.

(*c*) Where the Central Office is located in the same building as the Long-distance Office the loss due to the line between these offices may be neglected.

Addenda 3 and 4 to Appendix I give two examples of actual service conditions and are self-explanatory.

ADDENDUM 1 TO APPENDIX I.



CONVENTIONS.

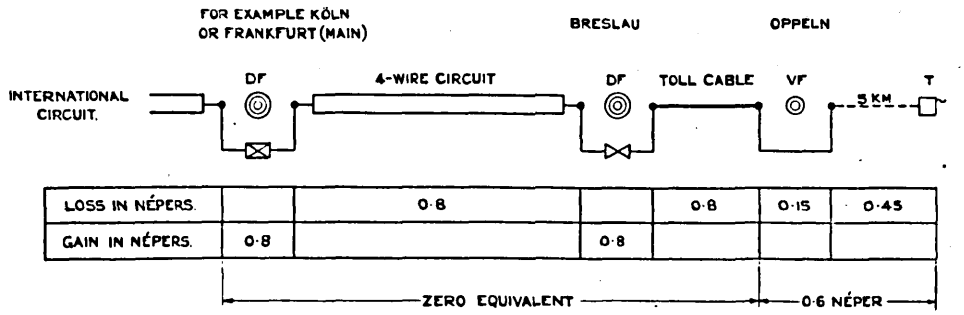
—C:::]—	DENOTES	4-WIRE TOLL CIRCUIT
———	•	2-WIRE TOLL CIRCUIT
———	•	JUNCTION LINE
- - - - - - -	•	SUBSCRIBER'S LINE
DF◎	•	PRINCIPAL TRANSIT CENTRE (WITH CORD CIRCUIT REPEATERS)
VF◎	•	TRANSIT CENTRE (WITH CORD CIRCUIT REPEATERS)
EF○	•	DISTRIBUTION CENTRE (WITHOUT CORD CIRCUIT REPEATERS)
VS TO F●	•	LOCAL EXCHANGE OF A DISTRICT WITH NO TOLL EXCHANGE
T□	•	SUBSCRIBER'S STATION

ADDENDUM 2 TO APPENDIX I.

Approximative Sub-division of the Maximum Values of the Reference Equivalents in the National Transmitting and Receiving Systems of the German Telephone Administration.

	For 100% of the subscribers.	In the future for 90% of the subscribers.
I.—National Transmitting System.		
A.—*Reference equivalent of the local transmitting system :*	Népers.	Népers.
1. Average transmitting reference equivalent of the subscriber's set (zero local line)	+ 0·55	+ 0·55
2. Tolerance, allowed for in the value of 1	+ 0·2	+ 0·2
3. Battery supply loss in the microphone	+ 0·25	+ 0·15
4. Effective attenuation of the current supply system in the Central Office	+ 0·1	+ 0·1
5. Effective attenuation in the subscriber's local line	+ 0·45	+ 0·3
6. Various losses in the Central Office	+ 0·05	+ 0·05
B.—*Losses in the circuit between the Central Office and the Long-distance Office :*		
1. Effective attenuation in that circuit	+ 0·3	+ 0·25
2. Effective attenuation in the Long-distance Office	+ 0·1	+ 0·1
Total	+ 2·0	+ 1·7
II.—National Receiving System.		
A.—*Losses in the circuit between the Central Office and the Long-distance Office :*		
1. Effective attenuation in that circuit	+ 0·3	+ 0·25
2. Effective attenuation in the Long-distance Office	+ 0·1	+ 0·1
B.—*Reference equivalent of the local receiving system :*		
1. Average receiving reference equivalent of the subscriber's set (zero local line) ...	— 0·2	— 0·2
2. Tolerance, allowed for in 1	+ 0·2	+ 0·2
3. Effective attenuation of the current supply system in the Central Office	+ 0·1	+ 0·1
4. Effective attenuation in the subscriber's line	+ 0·45	+ 0·3
5. Various losses in the Central Office	+ 0·05	+ 0·05
Total	+ 1	+ 0·8

ADDENDUM 3 TO APPENDIX I.



CONVENTIONS.

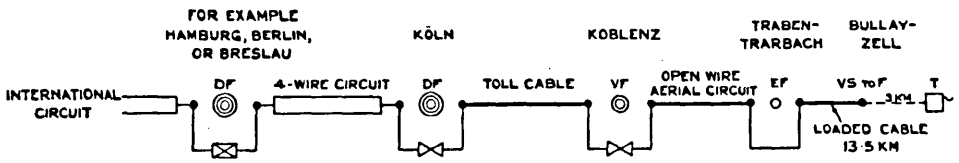
— DENOTES INTERCONNECTION 4-WIRE TO 4-WIRE INTRODUCING A TRANSMISSION GAIN.

— " CORD CIRCUIT REPEATER

" DIRECT INTERCONNECTION.

I. REFERENCE EQUIVALENT OF THE SENDING SYSTEM	1 EFFECTIVE ATTENUATION BETWEEN TRANSIT CENTRE (VF) AND SUBSCRIBER'S STATION (T)	0·6 NÉPER
	2. AVERAGE VALUE OF SENDING REFERENCE EQUIVALENT OF THE SUBSCRIBER'S STATION (WITH ZERO LINE)	0·55 "
	3 BATTERY SUPPLY LOSS.	0·25 "
	TOTAL	1·4 ± 0·2 NÉPER
II. REFERENCE EQUIVALENT OF THE RECEIVING SYSTEM	1 EFFECTIVE ATTENUATION BETWEEN TRANSIT CENTRE (VF) AND SUBSCRIBERS STATION (T)	0·6 NÉPER
	2. AVERAGE VALUE OF RECEIVING REFERENCE EQUIVALENT OF THE SUBSCRIBERS STATION (WITH ZERO LINE)	−0·2 "
	TOTAL	0·4 ± 0·2 NÉPER

ADDENDUM 4 TO APPENDIX I.



LOSS IN NEPERS		0·8		0·8		0·6	0·1	0·25	0·15	0·3
GAIN IN NÉPERS	0·8		0·8		0·6					

ZERO EQUIVALENT — 0·8 NÉPER

CONVENTIONS

DENOTES INTERCONNECTION 4-WIRE TO 4-WIRE INTRODUCING A TRANSMISSION GAIN

• CORD CIRCUIT REPEATER

• DIRECT INTERCONNECTION

I REFERENCE EQUIVALENT OF THE SENDING SYSTEM	1. EFFECTIVE ATTENUATION BETWEEN DISTRIBUTION CENTRE (EF) AND SUBSCRIBER'S STATION (T)	0·8 NÉPER
	2. AVERAGE VALUE OF SENDING REFERENCE EQUIVALENT OF THE SUBSCRIBER'S STATION (WITH ZERO LINE)	0·55 •
	3 BATTERY SUPPLY LOSS.	0·15 •
	TOTAL	1·5 ± 0·2 NÉPER
II REFERENCE EQUIVALENT OF THE RECEIVING SYSTEM	1 EFFECTIVE ATTENUATION BETWEEN DISTRIBUTION CENTRE (EF) AND SUBSCRIBER'S STATION (T)	0·8 NÉPER
	2 AVERAGE VALUE OF RECEIVING REFERENCE EQUIVALENT OF THE SUBSCRIBER'S STATION (WITH ZERO LINE)	-0·2 •
	TOTAL	0·6 ± 0·2 NÉPER

APPENDIX II.

NOTES BY THE FRENCH ADMINISTRATION CONCERNING THE PRACTICAL LIMITS OF THE REFERENCE EQUIVALENTS FOR NATIONAL TRANSMITTING AND RECEIVING SYSTEMS IN INTERNATIONAL TELEPHONE COMMUNICATION.

I. Organisation of the French Telephone Administration Network.

The network of the French Telephone Administration is organised on the following basis :—

Central Offices, equipped for long-distance service, are divided into three classes :—

1. Manual centres with continuous service.
2. Distribution centres.
3. Transit centres.

All the local offices are connected to the manual centres either by direct trunks or through other local networks. On the other hand, each manual centre is connected by direct trunks to at least one distribution centre and each distribution centre is connected by direct trunks to at least one transit centre. Each transit centre is equipped with cord-circuit repeaters.

All the international circuits, without exception, terminate in a transit centre.

In an international communication the term National Transmitting (or Receiving) System comprises the speaking (or listening) subscriber's set and the aggregate of connecting links between that subscriber and the office side terminals of the transformer of the international circuit. The make-up of the national system may vary considerably according to the subscriber and the international circuit involved.

In the particular case, where the distribution centre of a subscriber is also the transit centre and, in addition, the latter serves an international circuit, the national system is reduced to the connection between the subscriber's set and his distribution centre. In the more general case the distribution centre is connected to the international transit centre through one or more transit centres. In that case cord-circuit repeaters at the transit centres compensate for the losses in the lines, connecting, on the one hand, the distribution centre with the first transit centre and, on the other hand, those which interconnect the transit centres. It will be seen, therefore, that the maximum limits, recommended by the C.C.I. for the equivalent of a national system, *i.e.*, 2 népers (or, 1.7 népers for 90 per cent. of the subscribers) for the transmitting system and 1.3 népers (or, 1.2 népers for 90 per cent. of the subscribers) for the receiving system, apply to the system, comprising the subscriber's set and the aggregate of circuits and equipments between the subscriber and the distribution centre (including its office).

Before citing some typical examples of the sub-division of the equivalents, the method of calculating, approximately, the equivalents used by the French Administration will be described.

II. Determination of Reference Equivalents.

For the investigation of the transmission qualities of subscriber's instruments and telephone lines, the French Administration uses the working standard, " SETAC," described in the " Livre Jaune " (Proceedings of the C.C.I. Plenary Meeting in Brussels, 1930, p. 73, English Edition, p. 40). The solid-back microphones and the standard Bell receivers, mentioned in the above-cited page in the " Livre Jaune," are used. The microphone and receiver standards used in the French telephonometric service are periodically calibrated against the transmitting and receiving systems of the " SFERT " in order to check their stability.

The reference equivalents of the French Administration's " SETAC " system (this system contains resistances of 300 ohms) have the following values* :—

Reference equivalent of transmitting system	...	...	...	+0.75 néper
Reference equivalent of receiving system	...	...	...	0.0 néper

The subscriber's sets used in the telephone system of the French Administration are subjected to tests in order to check their efficiency. For C.B. subscriber's sets, for example, it is required that the set tested, when substituted for the standard set (transmitting or receiving respectively) of the " SETAC " shall not increase the transmitting (or receiving) system equivalent of the " SETAC " by more than 0.3 néper.

The service conditions of subscribers' sets influence the test conditions, particularly in respect to the voltage of the central office battery, the design of the battery supply apparatus and the characteristics of the subscriber's line circuit. The French Administration has measured, in terms of the " SETAC " transmitting (or receiving) system, the relative equivalent (*see* p. 31, English Edition, p. 16) of the transmitting (or receiving) system, made up of an Administration subscriber's set (assuming nominal efficiency), a subscriber's line circuit of variable length and characteristics and central office equipment of different types. For a given subscriber's line circuit and a given type of central office equipment the reference equivalent of the transmitting (or receiving) system, thus defined, is obtained by adding to the relative equivalent of that system the figures given above, *i.e.* :—

+0.75 néper for transmission.
0.0 néper for reception.

If, in addition, the most unfavourable condition is to be assumed, it is necessary to augment both values by the tolerances allowed for reception, such as, for example, the 0.3 néper admitted for the C.B. subscriber's set.

* These values are the latest ones observed in the " SFERT " Laboratory.

The reference equivalent of the transmitting or receiving system, comprising the subscriber's set and the line which connects him to the nearest office is determined by telephonometric voice tests. In order to deduce the national transmitting or receiving system equivalent it is necessary to take into account the losses in the lines which connect the subscriber's central office with the distribution centre as well as the losses in the various intermediary offices. In order not to complicate the calculation, which is only an approximation, the French Administration simply augments the reference equivalent of the system, comprising the subscriber's set and the line connecting it to the nearest office by the other losses mentioned, as measured at a frequency of 800 p : s.

III. Typical Examples of the Sub-division of the Reference Equivalents in the National Transmitting (or Receiving) Systems.

1st Example—Subscriber in Paris.

A.—*Transmitting.*	Néper.
Loss in Long-distance Office	+ 0·2
Maximum loss in the circuit connecting the Long-distance Office with local office	+ 0·35
Loss in the local office (loss due to cabling)	+ 0·10
Relative equivalent (transmitting) of the system comprising a C.B. subscriber's set, a 3 km length of 0·6 mm cable conductors and the office equipment (intermediary offices in Paris)	— 0·25
Reference equivalent of transmitting system of the French Administration's working standard	+ 0·75
Tolerance of subscriber's set	+ 0·30
Maximum reference equivalent of the national transmitting system	+ 1·45

B.—*Receiving.*	
Loss in Long-distance Office	+ 0·20
Maximum loss in the circuit, connecting the Long-distance Office with local office	+ 0·35
Loss in the local office (loss due to cabling)	+ 0·10
Relative equivalent (receiving) of the system comprising a C.B. subscriber's set, a 3 km length of 0·6 mm cable conductors and the office equipment (intermediary offices in Paris)	— 0·05
Reference equivalent of receiving system of the French Administration's working standard	+ 0·00
Tolerance of subscriber's set	+ 0·30
Maximum reference equivalent of the national receiving system	+ 0·90

2nd Example—Rural Subscriber.
(Local Battery Subscriber's Set.)

A.—*Transmitting.*	Néper.
Maximum over-all equivalent, corresponding to :	
(1) Loss in the junction circuits, connecting the terminals of the line transformer of the long-distance circuit (in the distribution centre) with the terminals of the subscriber's set ;	
(2) Losses in intermediary offices (distribution centre, manual centre and rural automatic offices)	+ 1·00
Relative equivalent (transmitting) of the system, comprising an L.B. subscriber's set (with maximum tolerance and with dry cells at their lowest voltage), and zero subscriber's loop	— 0·05
Reference equivalent of the transmitting system of the working standard	+ 0·75
Maximum reference equivalent of the national transmitting system	+ 1·70

B.—*Receiving.*	
Maximum over-all equivalent, corresponding to :	
(1) Loss in the junction circuits, connecting the terminals of the line transformer of the long-distance circuit (in the distribution centre) with the terminals of the subscriber's set ;	
(2) Losses in intermediary offices (distribution centre, manual centre and rural automatic offices)	+ 1·00
Relative equivalent (receiving) of the system, comprising an L.B. subscriber's set (with maximum tolerance and with dry cells at their lowest voltage), and zero subscriber's loop	+ 0·15
Reference equivalent of the receiving system of the working standard	+ 0·00
Maximum reference equivalent of the national receiving system	+ 1·15

Note.—In certain cases (not exceeding 10 per cent.) the above stated equivalents are slightly exceeded ; the loss in the circuit between the subscriber and the distribution centre may exceed 1.00 néper, but not 1.15 népers. The maximum limits of the national transmitting and receiving system equivalents then become 1.85 and 1.30 népers in exceptional cases. Below is given another example of an unfavourable case, in which the maximum permissible limits are on the border line, affecting a small percentage of subscribers.

3rd Example—Satellite Subscriber.

(Subscriber in Roncq, an automatic satellite to the automatic exchange in Tourcoing, served by the long-distance office in Lille, which is a distribution centre; the subscriber has a C.B. set with battery supply from Roncq.)

A.—*Transmitting.*	Néper.
Loss in the Lille long-distance office	+ 0·15
Loss in the circuit, Lille-Tourcoing	+ 0·40
Loss in the Tourcoing office	+ 0·10
Loss in the circuit Tourcoing-Roncq	+ 0·45
Relative equivalent (transmitting) of the system comprising a C.B. subscriber's set, a subscriber's loop of 2 km 0·6 mm cable conductors and office equipment in Roncq	— 0·15
Reference equivalent of the transmitting system of the working standard	+ 0·75
Tolerance of the subscriber's set	+ 0·30
Maximum reference equivalent of the national transmitting system	+ 2·00

B.—*Receiving.*	
Loss in the Lille long-distance office	+ 0·15
Loss in the circuit, Lille-Tourcoing	+ 0·40
Loss in the Tourcoing office	+ 0·10
Loss in the circuit Tourcoing-Roncq	+ 0·45
Relative equivalent (receiving) of the system comprising a C.B. subscriber's set, a subscriber's loop of 2 km 0·6 mm cable conductors and office equipment in Roncq	— 0·15
Reference equivalent of the receiving system of the working standard	+ 0·00
Tolerance of the subscriber's set	+ 0·30
Maximum reference equivalent of the national receiving system	+ 1·25

APPENDIX III.

SUB-DIVISION OF THE REFERENCE EQUIVALENT IN THE BRITISH NATIONAL TRANSMITTING AND RECEIVING SYSTEMS.

In Great Britain there is only one "bureau tête de ligne" for international circuits, viz., London.

London is connected by direct circuits to the following main centres (marked *Z* in the diagram, p. 72): Aberdeen, Edinburgh, Glasgow, Newcastle, Middlesbrough, Leeds, Sheffield, Hull, Manchester, Liverpool, Birmingham, Nottingham, Leicester, Cambridge, Lowestoft, Bristol, Cardiff, Swansea, Plymouth, Southampton.

For connection to these centres in the majority of cases circuits of zero equivalent have been provided exclusively for international calls. When such circuits are not available, a circuit suitable for the insertion of cord-circuit repeaters at London is provided, and this gives an overall loss of zero to the main centre (*Z*).

From these main centres (*Z*) to subsidiary centres (*G*) circuits having an average attenuation loss of 3 db (maximum 6 db) are provided.

From these subsidiary centres (*G*) to local exchanges (*D*) circuits having an average attenuation loss of 3 db (maximum 5 db) are provided.

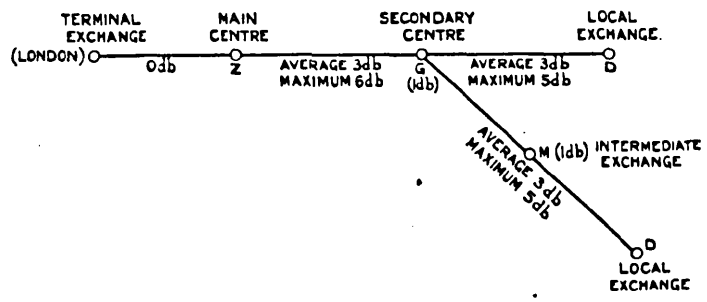
In cases where the sum of the attenuation losses from (*Z*) to (*D*) exceeds 6 db, a cord-circuit repeater is inserted either at (*Z*) or at (*G*), as may be found most convenient, the attenuation loss between (*Z*) and (*D*) being thereby reduced to a figure not exceeding 6 db.

An additional loss of 1 db may be incurred at each of two switching points (*G*) or (*M*).

The normal maximum reference equivalent for the subscriber when speaking (overall attenuation between (*D*) and the subscriber) is 9.7 db.

The maximum for the subscriber when listening is 2.1 db.

The arrangements are shown diagrammatically as follows :—



When conditions are found to be such that transmission losses are likely to be excessive, special measures are taken to reduce these, *e.g.*, by the use, as previously stated, of cord-circuit repeaters or by fitting special instruments, or by the reduction of the resistance of the local C.B. subscribers' lines.

The above conditions at present apply to *all* subscribers to whom full trunk facilities are guaranteed enabling them to obtain connections to the international European network.

As regards the future, a scheme is in hand for general transmission improvement in Great Britain. Under this plan, the attenuation loss between (*Z*) and (*G*) will be eliminated and this will correspondingly improve the " Reference Equivalent " for international communications to and from Great Britain.

The following typical concrete examples are given to illustrate the present position in Great Britain.

1. A subscriber in Crantock speaks via Newquay (intermediary exchange), Truro (subsidiary centre) to Bristol (main centre).

		db
Z.	London Exchange	
	London-Bristol Trunk	Zero
Z.	Bristol Exchange	
	Bristol-Truro Trunk	6
G.	Truro Exchange	1·0
	Truro—Newquay Trunk	1·3
M.	Newquay Exchange	1·0
	Newquay—Crantock Trunk	1·0
D.	Crantock Exchange and Subscriber (speaking)	
	Reference equivalent of local transmitting system	9·7
		20·0
	Cord Circuit Repeater at Bristol	— 10·0
	Reference Equivalent of national transmitting system	10·0

The allowance for Crantock Exchange and subscriber when receiving is 2.1 db. The total allowances from London under those conditions is therefore 2.4 db.

2. A subscriber in Lyth speaks via Wick (intermediary exchange), Inverness (subsidiary centre) to Aberdeen (main centre).

		db
Z.	London Exchange London—Aberdeen Trunk	Zero
Z.	Aberdeen Exchange Aberdeen—Inverness Trunk	5·1
G.	Inverness Exchange Inverness—Wick Trunk	1·0 10·0
M.	Wick Exchange Wick—Lyth Trunk	1·0 0·8
D.	Lyth Exchange and Subscriber (speaking) Reference Equivalent of local transmitting system	 9·7
		27·6
	Cord Circuit Repeater at Inverness	— 12·0
	Reference Equivalent of national transmitting system	15·6

The allowance for Lyth Exchange and subscriber when receiving is 2.1 db. The total allowance from London under those conditions is therefore 8 db.

3. A subscriber in Hampton speaks via Malpas (intermediary exchange), Chester (subsidiary centre) to Liverpool (main centre).

		db
Z.	London Exchange London—Liverpool Trunk	Zero
Z.	Liverpool Exchange Liverpool—Chester Trunk	2·3
G.	Chester Exchange Chester—Malpas Trunk	1·0 1·7
M.	Malpas Exchange Malpas—Hampton Trunk	1·0 0·5
D.	Hampton Exchange and Subscriber (speaking) Reference Equivalent of local transmitting system	 9·7
	Reference Equivalent of national transmitting system	16·2

The allowance for Hampton Exchange and subscriber when receiving is 2.1 db. The total allowance from London under those conditions is therefore 8.6 db.

APPENDIX IV.

SUB-DIVISION OF TRANSMITTING AND RECEIVING EQUIVALENTS IN THE TOLL NETWORK OF THE BELL SYSTEM, UNITED STATES OF AMERICA.

The toll plant in the United States of America is engineered in accordance with the "General Toll Switching Plan," described by Mr. H. S. Osborne in Monograph B-485 of the Bell Telephone System Technical Publications. Under this plan, offices are classified as regional centres, primary outlets and toll centres. Regional centres have been established at Atlanta, Chicago, Dallas, Denver, Los Angeles, New York, St. Louis and San Francisco, and direct toll circuits have been set up between each regional centre and every other regional centre. It will be noted that New York City, in addition to being a regional centre, also serves as the terminal for all European and South American circuits to the U.S.A. Primary outlets have circuits to at least one regional centre and toll centres have circuits to either primary outlets or regional centres. All regional centres and primary outlets are provided with arrangements to introduce gain on switched connections.

The regional centre is in general a switching point for a large area, there being only eight in the whole of the United States. Accordingly, it is thought that the equivalents from subscriber's station to the regional centre by which it is served will be of interest. The breakdown of these equivalents into their component parts, in accordance with the standards of design being followed in this country, is shown by the following table. The total transmitting and receiving equivalents shown in this table include all losses between the subscriber's station and the switchboard terminal of the regional centre—regional centre circuits.

	Toll Terminal Equivalent *See* (A)		Toll Circuit Equivalent *See* (B)	Total Equivalent *See* (C)		
	Transmitting	Receiving		Transmitting	Receiving	Average of Transmitting and Receiving
	db	db	db	db	db	db
Maximum { Long Loop Office	9·00	5·00	7·00	16·0	12·0	14·0
Maximum { Short Loop Office *See* (D)	7·5	6·5	7·00	14·5	13·5	14·0
90% of stations are better than	—	—	—	14·0	11·0	12·5
Average of all stations ...	—	—	—	10·0	8·0	9·0

(A) Equivalent between subscriber's station and the toll board serving the subscriber.

(B) Equivalent between the toll board serving the subscriber and the regional centre to which this toll board is connected.

(C) The total Equivalent is a combination of the preceding columns referred to in (A) and (B) and represents all of the lines and apparatus between the subscriber and the regional centre to which he is connected as described in (B).

(D) For transmission design purposes in the United States, local central offices are graded in accordance with the average of the transmitting and receiving losses of the longest loops which they serve.

The toll circuit equivalent shown is on an effective basis, that is, it includes the necessary allowance for noise and distortion impairments in terms of the master reference system. Where the new terminal repeater switching pad arrangements are involved at the gain switching offices, the equivalent for the toll circuit given above assumes that switching pads at all the intermediate switching points are removed. Correspondingly, the gain of the cord-circuit repeaters is deducted if these are involved.

The transmitting and receiving equivalents shown above for the "toll terminal equivalent" are not entirely on an effective basis, although work is now actively under way to place the local plant design on this basis.

For the maximum condition when a connection to a transatlantic circuit is involved, an additional 3 db is added to the toll circuit equivalent shown above for the regional centre—regional centre circuit. In the U.S.A. it has been found that echo factors and variations in circuit equivalents with the distances involved make it undesirable at the present time to design the majority of the regional centre—regional centre circuits to meet a lower via equivalent.

Adoption of Arrangements in regard to Type of Loading and Gauge of Conductors, other than those prescribed by the C.C.I.

The International Consultative Committee—

Unanimously advises :—

That the types of loading and gauges of conductors, adopted as standards by the C.C.I., provide sufficient flexibility to meet all practical requirements in regard to the spacing of repeater stations.

However, cases may occur where standard types of line cannot be used. Care must then be taken that the performance clauses of the specifications issued by the C.C.I. are observed, particularly those relating to cut-off frequency, characteristic impedance and attenuation/frequency curves and, if possible, that the type of loading called for in the C.C.I. specifications is adopted.

In case it is proposed to increase the diameter of the conductors the International Consultative Committee would point out that it is more difficult to obtain a uniform distribution of the electrical constants of the line with large diameter conductors. Consequently, when it is essential to increase the diameter of the conductors in order to reduce the attenuation of a particularly long repeater section, it may be necessary to select so large a diameter that the attenuation of the repeater sections falls below the normal value. In this manner it is possible to operate the circuit with reduced repeater gains and thus obtain the same degree of stability as that of a standard type of circuit.

Possibilities of using Sections of Non-loaded Cable for International Telephony.

The International Consultative Committee—

Considering :—

That the use of sections of non-loaded cable presents technical and economical advantages over the use of loaded sections in certain particular cases; for example, for certain submarine cables, but that sections of non-loaded cable have only been used up to the present on a reduced scale in international telephony,

Recommends :—

That, through lack of experience, the systematic use of non-loaded cables for international telephone service cannot be recommended; but that nevertheless, in certain particular cases, each of which must be specially studied (for example, in the case of submarine cables), it is possible to employ, for international telephony, sections of non-loaded cable provided the C.C.I. recommendations on the following subjects are met: bands of frequency effectively transmitted (*see* p. 80, "Livre Rouge," p. 136); distortion (*see* p. 175, "Livre Rouge," p. 298); minimum and maximum levels (*see* p. 181, "Livre Rouge," p. 300); stability (*see* p. 182, "Livre Rouge," 302); absence of noise (Guiding principles of the C.C.I. for protection against the disturbing influences of high tension installations); phase distortion (Maximum duration of transient phenomena, *see* p. 77, "Livre Rouge," p. 130).

Echo Effects.

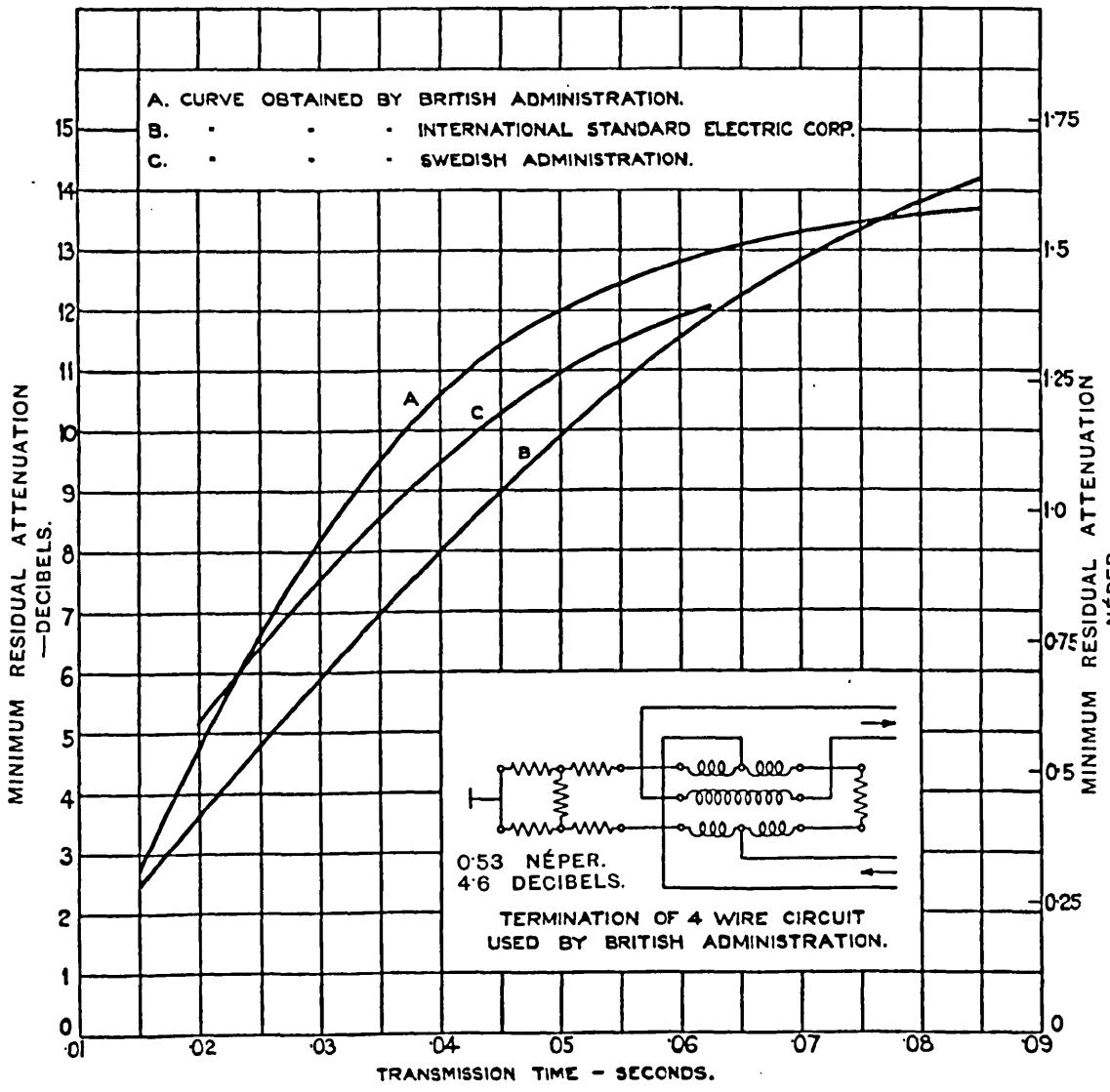
The International Consultative Committee—

Considering :—

That, as a result of practical tests, the maximum distances over which it is possible to transmit commercial speech without the use of echo suppressors are as shown on the curve chart (below),

Unanimously advises :—

1. That, for the present, all international circuits which exceed the limits indicated by these curves should be specially tested for the presence of echo effects and special means provided for their reduction, if necessary. (Echo Suppressors.)


A. CURVE OBTAINED BY BRITISH ADMINISTRATION.
B. • • • INTERNATIONAL STANDARD ELECTRIC CORP.
C. • • • SWEDISH ADMINISTRATION.
A
B
C
MINIMUM RESIDUAL ATTENUATION —DECIBELS.
MINIMUM RESIDUAL ATTENUATION —NÉPER.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0 0·25 0·5 0·75 1·0 1·25 1·5 1·75
·01 ·02 ·03 ·04 ·05 ·06 ·07 ·08 ·09
TRANSMISSION TIME - SECONDS.
0·53 NÉPER.
4·6 DECIBELS.
TERMINATION OF 4 WIRE CIRCUIT
USED BY BRITISH ADMINISTRATION.

2. That, in any case, considering the simplicity and reliable operation of echo suppressors, together with the fact that 4-wire circuits are often connected to repeater-operated 2-wire circuits, it is recommended that all 4-wire international circuits which may be extended beyond 500 km (" medium-heavy ") or 1 000 km (" extra-light ") should be equipped with echo suppressors.

3. That, in general, long circuits can be considerably improved by the use of echo suppressors, and that, when such provision is made, echo effects will not influence the range of speech.

Time of Propagation.

The International Consultative Committee—

Unanimously recommends :—

(*a*) That it is necessary, in a continental communication, to limit the time of propagation on each of the two transmission paths to a provisional value of 250 milliseconds, which corresponds, for connections equal to or less than 8000 km, to a minimum velocity of propagation of 32000 km/sec. and still higher velocity for connections greater than 8000 km, where the velocity of propagation should be as great as technical and economic consideration will allow.

(*b*) That it is desirable, for an inter-continental communication, when economic conditions will allow, to limit the time of propagation on the connection between the subscriber and the terminals of the inter-continental circuit in the same continent, to a provisional value of 100 milliseconds, which corresponds, for connections equal to or less than 3000 km, to a minimum velocity of propagation of 32 000 km/sec. and requires a still greater velocity of propagation for longer connections.

(*c*) That it is necessary, in the case of a continental communication, to arrange that the time of propagation on that part of the connection between the two voice-operated devices (echo suppressors or reaction suppressors) which are the greatest distance apart should not exceed a value fixed provisionally at 100 milliseconds.

Transient Phenomena.

The International Consultative Committee—

Unanimously advises :—

That the duration of transient phenomena for any frequency in the frequency band to be transmitted must not exceed 30 milliseconds for the complete connection between terminal exchanges.

Star-quad Cable for Long-Distance International Circuits.

The International Consultative Committee—

Unanimously advises :—

1. That from a technical point of view star-quad cables are suitable for international telephone circuits in so far as these cables meet the general conditions laid down in the specification for factory lengths and for repeater sections.

2. That whether star-quad cables in any given case should be preferred is purely a question of economics.

Considering, on the other hand :—

That the simultaneous use of phantom cables and star-quad cables without phantoms, as portions of a telephone circuit, presents difficulties in so far that star-quad cables render it necessary to change over at junction points from phantom working to physical circuits.

Unanimously advises :—

That, in order to preserve homogeneity of 2-wire repeater circuits in the repeater sections, it must be arranged that star-quad cables, in every case, be used only throughout complete repeater sections.

Paired Star-quad Cable for Long-Distance International Circuits.

That the use of paired star-quad telephone cables is admissible in international service on the condition that the important characteristics of these cables conform to the advice by the C.C.I. (particularly as regards type of loading, effective frequency band to be transmitted, etc.).

Uniformity.*

The International Consultative Committee—

Considering :—

That it is desirable, in order to ensure a satisfactory performance of the repeaters as well as to avoid reflection losses, to obtain a uniform distribution of the electrical constants throughout a repeater section,

Unanimously advises :—

That cable sections between repeater stations in one and the same country should be absolutely uniform throughout; that it should be prescribed that the construction of the cables shall be such that the circuits shall be perfectly balanced and the electrical constants uniformly distributed.

Considering, however :—

That, for the design of cable sections, extending over the frontier of two contiguous countries, it may, in certain cases, be necessary to join two sections of cable which do not fulfil the requirements of the same specification, and that certain connections of this kind have given good results, but that no deterioration in quality should be permitted as a result of any departure from the principle of uniformity,

Unanimously advises :—

That uniformity in the make-up of international cable sections between repeater stations, located on either side of a frontier, is very desirable, but that, in exceptional cases, a direct connection may be sanctioned between sections of cable made to different specifications, provided that the conditions relating to impedance balance laid down in the paragraph on " Impedance balance " in the " Essential clauses of a typical specification for repeater sections of loaded international telephone cable " are fulfilled (Appendix B.d.2, No. 3).

Note.—Uniformity of repeater sections is particularly important for circuits made up of 1·3 and 1·4 mm conductors; but in view of the fact that these circuits have almost the same total capacity per loading section in systems 1*a* and 1*b* sufficient degree of uniformity is obtainable, if in a complete repeater section, one or the other of the two types of loading coils is used, keeping the characteristics of systems 1*a* and 1*b*, respectively as regards the equipment of the cable proper in the sections to be joined.

Frequency of Ringing Currents.

The International Consultative Committee—

Considering :—

That, for convenience of international relations, it is desirable to adopt a single frequency for ringing; that this frequency should be sufficiently high for ringing currents to be transmitted by repeaters under normal conditions; that experiments made in various countries with currents of a frequency of 500 periods per second have given satisfactory results; that the disturbing effect of crosstalk due to currents of a frequency of 500 periods per second is generally less than the crosstalk due to currents of a higher frequency; that in order to avoid false calls due to currents other than the signalling currents, it is desirable, in the present state of telephone engineering development, to modulate or interrupt at low frequency the currents of voice frequency.

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* *See* Appendix C.*b*.1, entitled: " Different ways in which two Telephone Administrations can co-operate in the construction of a repeater section which crosses a frontier." (*Livre Jaune*, pp. 482-488, English Edition, pp. 291-295.)

Unanimously advises :—

1. That, for the time being, for circuits used for international communications a sinusoidal signalling current should be chosen having a frequency of 500 p : s ±2 per cent. interrupted in accordance with a frequency lying between 20 and 25 p : s and having an effective power in the uninterrupted current fixed provisionally between 3 and 6 milliwatts at points of zero transmission level.

2. That it is desirable to use, whenever possible, an interrupted frequency of 20 p : s ; this permits great selectivity of the apparatus for receiving calling currents.

3. That, when agreement is reached between Administrations concerned, it is possible to use a ringing current of 500 p : s uninterrupted, provided that the circuits on which this method of signalling is used are not likely to be connected through one of their terminal exchanges to another international circuit using a ringing current of 500 p : s interrupted at 20 p : s.

4. That, in the case of 2-wire circuits of short length not used for infra-acoustic telegraphy, when agreement has been reached between the Administrations concerned, it may be economical to employ a ringing current of low frequency (frequency between 16 and 25 p : s).

5. That, when using long distance automatic selection, it is absolutely necessary that special precautions should be taken to prevent the apparatus for receiving the ringing currents and that for receiving the long distance selecting signals being operated in error.

6. That operators should be instructed to send out ringing current of at least two seconds' duration on international telephone circuits.

Choice of a Single Frequency for Routine Measurements.

The International Consultative Committee—

Considering :—

That it is desirable to have, for routine measurement, a current of definite frequency which is always the same ; that this frequency should be as near as possible to that of the average frequency of spoken sounds ; that it has been provisionally admitted, up to the present, that this frequency should be 800 periods per second and that the experience hitherto acquired with currents of different frequency appears to be still inadequate to enable one to consider a change in the present practice.

Unanimously advises :—

That currents of a frequency of 800 periods per second should continue to be employed for tests and measurements on international circuits.

Single Frequency Methods, suitable to replace Voice Tests.

The International Consultative Committee—

Considering :—

That the choice of the frequency for currents used in routine maintenance tests should be of such a nature as to facilitate the investigation of faults in the various types of circuits commonly used ;

That in modern telephony, it is becoming increasingly important to consider not only the volume of the sound transmitted, but also the articulation of the speech transmitted ;

Considering, on the other hand :—

That testing methods, using single frequency, have been proposed, and that these give results comparable with voice tests, namely :—

(*a*) A method using a rhythmic frequency with an integrating receiving device. (*See* information furnished by the British Delegation, published in the Report of the Plenary Assembly of the C.C.I., Paris, 1926, p. 173. English Translation 1926, p. 101.)

(*b*) A method based on crosstalk measurements at a few frequencies only, the results obtained being interpreted according to a method determined by each country, taking into account the phonetic characteristics of the language of the country (*see* information furnished by the German Delegation and published in the account of the proceedings at the Plenary Assembly of the C.C.I. in Paris, 1926, p. 174. English Translation 1926, p. 104. Also Appendix C.a.1., No. 1, attached, entitled :—" Notes on Crosstalk, submitted by the French Delegation " ; Appendix C.a.1, No. 2, attached, entitled : " Notes by the German Administration on the Measurement of Crosstalk " ; Appendix C.a.1, No. 3, attached, entitled : " Notes by Dr. H. Jordan concerning Measurement of Crosstalk " ; Appendix C.a.1, No. 4, attached, entitled : " Report of the British Post Office concerning Measurement of Crosstalk " ; Appendix C.a.1, No. 5, attached, entitled : " Report of the International Standard Electric Corporation " ; and Appendix C.a.1, No. 6, attached, entitled : " Proposals of the Swiss Administration for the Measurement of Crosstalk.")

Considering further :—

That these methods are not yet sufficiently confirmed by experience and that it is necessary to continue the study of their mode of application,

Unanimously advises :—

That the voice test, prescribed in the paragraphs on " Crosstalk " in the typical specifications for international telephone cables shall provisionally be maintained, but that it is necessary to study, as soon as possible, a testing method for crosstalk which shall be independent of the testing conditions. The various Administrations and Operating Companies are therefore invited to examine the different methods under consideration and give their views on this point.

Use of International Circuits for the relaying of Radio-broadcast Transmissions.

The International Consultative Committee—

Considering :—

That broadcasting has become an important element in social life.

That experience has shown that the exchange of broadcast programmes over considerable distances can best be done by the use of long-distance telephone lines, capable of reproducing correctly all musical frequencies and protected against atmospheric disturbances which frequently affect radio transmissions.

That the relaying of broadcasting transmissions by means of international circuits, from an economical standpoint, has the double advantage of utilising the circuits during the slack hours and of obtaining from several broadcasting stations excellent programmes of high artistic standard, which otherwise would entail a considerable expense, and lectures or speeches of general interest.

Unanimously advises :—

That it is desirable that radio-broadcast transmissions should be effected on international circuits.

Frequency Band to be Transmitted for Different Qualities of Broadcast Transmissions.

The International Consultative Committee—

Considering :—

That, as regards the frequency band to be transmitted for the reproduction of speech and music, it is necessary to discriminate in each case in practice between what is desirable as an ideal and what can be accomplished, having due regard to the various economical factors involved,

Unanimously advises :—

That an ideal reproduction of speech and music necessitates a distortionless transmission of the currents comprising the entire range of frequency between 30 and 10000 periods per second; that the transmission of very low frequencies (30 to 100 p : s) is more important from this standpoint than that of the higher frequencies, and that an extension beyond 10000 periods per second of the band of frequency effectively transmitted would not be of any particular advantage.

That the transmission of a frequency range from 50 to 6400 periods per second is adequate for the reproduction of good quality music and perfect speech. (*See* p. 85, "Livre Rouge," p. 144, under the recommendations, entitled: "Electrical conditions to be considered as a criterion for the good condition of lines for relaying radio broadcast transmissions," paragraph 1, concerning the variations in the equivalents and levels as a function of the frequency in the case of a telephone circuit used for broadcast transmission.)

Possibility of Standardisation of Long-Distance Telephone Systems.

The International Consultative Committee—

Considering :—

That it is desirable to improve, from the experience gained, the existing long-distance systems in Europe, by modifying the present characteristics which determine the quality of transmission (cut-off frequency, frequency range transmitted, etc.),

Unanimously advises :—

(*a*) That it is desirable to standardise the secondary electrical characteristics of the cables, particularly the frequency band to be transmitted and the admissible limits* for the variation of the transmission equivalent as a function of the frequency; it is, however, not necessary to standardise any further.

(*b*) That owing to the difficulties due to the existence, in certain countries, of large networks, and of the conditions which have to be met when planning new cable schemes, it is not practicable to standardise details of cable circuit characteristics such as loading coil spacing, diameter of conductors, etc.

(*c*) That it is necessary to lay down by way of example, detailed specifications. (*See* specifications corresponding to each of Systems Ia, Ib and II, recommended by the C.C.I.)

(A.b.) General Rules Concerning the Make-up of Transmission Systems

(A.b.1.) Ordinary Telephony.

Inter-Connection of Four-Wire Circuits. †

The International Consultative Committee—

Considering :—

That it is desirable that circuits already earmarked for transit traffic or capable of eventually being inter-connected should be established in such a manner as to operate with full efficiency when they ultimately form part of the projected long-distance network, although their provisional use for traffic between terminal stations may not be economical.

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* For commercial telephony and also, in general, for photo-telegraphy, frequency is said to be effectively transmitted when the equivalent at that frequency does not exceed the equivalent at 800 p : s more than 1.0 néper or 8.7 decibels. For broadcast transmissions, frequency is said to be effectively transmitted when the equivalent at that frequency does not exceed the equivalent at 800 p : s more than 0.5 néper or 4.3 decibels.

† This replaces the text under the same title on pp. 244-5 in *Livre Jaune* (English Translation p. 140).

That for making connections between long 4-wire circuits, it is desirable preferably to adopt methods of connection which do not introduce prejudicial echo effects.

That it is desirable to point out, in regard to this matter, that cord-circuits have been designed with a view to permitting the extension of a long 4-wire circuit by means of another 4-wire circuit (with or without the introduction of additional telephone repeaters) without its being necessary for the operator to make any adjustment.

Unanimously advises :—

That where two 4-wire circuits have to be joined together, it is desirable to make this connection by switching arrangements designed in such a manner that :—

1. Additional echo effects are not produced.
2. Adjustments of the repeaters are not necessary.
3. The level in neither is changed by more than ± 0.2 neper (± 1·7 decibels).

(A.b.2.) Carrier Telephone Circuits.

Frequency Band to be Transmitted on High Frequency Carrier Circuits.

The International Consultative Committee—

Unanimously advises :—

That for circuits used for high frequency carrier currents it is desirable that the effective frequency band transmitted (frequencies at which the value of the equivalent does not exceed by more than 1.0 néper or 8.7 decibels the value of the equivalent measured at 800 p : s) lies between 300 and 2000 p : s at least.

Draft of Model Questionnaire for Preliminary Information in regard to existing Lines and Offices, to be obtained by Telephone Administrations wishing to establish Carrier Current Telephone Installations.

The C.C.I. unanimously advises that the following questionnaire be used :—

1. What communication channels should be installed by means of high frequency carrier currents ?

2. What lines are available for the installations of high frequency apparatus ?
   (*a*) The length of these lines.
   (*b*) Diameter, nature of conductors, distance between conductors.
   (*c*) Existing cable sections (situation, type and length of these cables).
   (*d*) Existing crosses and transpositions.
   (*e*) Among the lines available, are there two or more identical circuits which may be interchanged, and from which spare circuits can be obtained ?

3. Which intermediate localities are suitable for the installation of repeaters ? Where have low frequency repeaters already been inserted on lines which are to be equipped for high frequency ?

4. What are the sites of radio stations likely to affect high frequency communication ? What are the powers and frequencies used by these stations ?

5. Should the new high frequency channels be connected to other lines, either permanently or from time to time ?

6. The replies to the above questions having rendered possible the retention of certain circuits and localities, Administrations should obtain the following information:—

What are the results of the impedance and attenuation tests made on each of the sections of line over the whole frequency range to be used?

Note.—*See* Appendix B.*b*.2, No. 1: "Instructions for drawing up a typical specification for the supply of a multiple telephone installation using high frequency carrier currents for international service," and Appendix B.*b*.2, No. 2: "Instructions for drawing up a specification for the supply of a high frequency repeater station."

(A.b.3.) Radio-broadcast Transmission.*

Conditions which Open-Wire Lines must fulfil in order to be used for Radio-Broadcasting

The International Consultative Committee—

Unanimously advises:—

(*a*) That in all cases where parasitic noises or interferences, due to mutual induction between the open-wire lines used for broadcasting and other circuits, do not enter into consideration, these open-wire telephone lines are in every respect suitable for broadcasting purposes.

(*b*) That one should not forget that the necessary freedom from inductive interference can only be obtained on circuits which are very carefully balanced and maintained.

(*c*) That no serious distortion would be caused by the introduction of short, non-loaded cable lengths on open-wire lines, such as are used for railway and river crossings, etc. If long, loaded cables are inserted, the effects may be more serious. In the case of long cable lengths, the cut-off frequency must meet the conditions relating to the range of frequency to be transmitted for the various qualities of broadcast transmission (p. 80).

(*d*) That when amplification is necessary on open-wire lines used for broadcasting, it is desirable that the attenuation of the line between two successive repeater stations should not exceed 1 néper or 8.68 decibels.

(*e*) That with respect to the value of the input power applied to the repeaters, vacuum tubes should be employed which are capable of dealing with 100 mW. without undue non-linear distortion. The repeaters to be used must have a very flat frequency characteristic curve over a range of 30 to 10000 periods per second.

Alterations made in Cable Circuits in order that they may be suitable for Broadcast Transmission.†

The International Consultative Committee—

Having regard to the considerations laid down in the recommendation "Frequency band to be transmitted for different qualities of broadcast transmission,"

Unanimously advises:—

1. That cable circuits for radio-broadcasting require a different value of cut-off frequency. In medium-heavy loaded quads, the phantom circuits of which have a cut-off frequency of approximately 3800 periods per second, these circuits can only be used for transmissions over which a range up to 3000 periods per second is sufficient. For broadcasting transmissions of a higher standard, extra-light loaded side and phantom-circuits are usable, with a preference for the phantom-circuits.

* This text replaces the one under the same title which appears on pp. 246 to 250 of the *Livre Jaune* (English Edition, pp. 141-143).

† *See* Appendix B.*b*.3, No. 1 "Essential clauses of a typical specification for the supply of repeaters and special correctors for the relay of radio broadcast transmissions."

2. In long-distance cables of the types specified by the C.C.I. (Systems 1 and 2 of the Typical Specification of Loading, contained in Appendix B.d.2, No. 3), when specially loaded circuits have been reserved for the relaying of broadcast transmission, it would be possible, both economically and technically, to prescribe for these circuits a cut-off frequency of approximately 10000 periods per second.

That if these special circuits are shielded, the shield should be earthed; in such special cases, where the need for segregation is less urgent and the circuits are in the outer layer, it is better not to use shielding and thereby save expense.

3. That with respect to the repeaters, it is necessary that the frequency curve of amplification and the frequency curve of the equivalent of the circuit coincide. This coincidence should take place with a maximum allowable deviation of ± 0.15 néper or ± 1.3 decibel within the frequency ranges required for the different types of broadcast transmission. On the basis of the advice already given vacuum tubes may have to be used which are capable of dealing with a power of the order of 100 milliwatts in order to avoid non-linear distortion.

Electrical Conditions to be considered as a Criterion for the Good Condition of Lines for Relaying Radio Broadcast Transmissions.

The International Consultative Committee—

Unanimously advises :—

Relative Transmission Levels. At any point of a circuit relaying radio broadcast transmissions the relative power level measured at 800 cycles should not be greater than 1.15 népers (10 decibels). This assumes that the relative zero level on such circuits is the same as that of an ordinary telephone circuit, that is the point of the telephone system at which a constant maximum power of 5 mW can be applied without risk of serious distortion. The relative minimum power level should be such that the ratio between the maximum useful voltage to the noise and crosstalk voltage is at least 1000 : 1 (6.9 népers or 60 decibels) for cable circuits and at least 400 : 1 (6 népers or 52 decibels) for open wire lines.*

The nominal value of the relative power level at the output of a repeater nearest the frontier should be $+0.90$ néper (8 decibels) with a tolerance of ± 0.2 néper (2 decibels). The relative level of the output voltage of the repeater nearest the frontier should be the same for all frequencies transmitted with a tolerance of ± 0.2 néper (2 decibels).

Equivalents. The equivalent, that is the difference between the relative transmission level measured at the beginning (output of the first repeater) and the relative transmission level measured at the end (output of last repeater) of a complete telephone circuit for relaying radio-broadcast transmissions, should be equal to zero at a frequency of 800 cycles with a permissible deviation of ± 0.3 néper (2.6 decibels).

Adjustment of Equalisers. Administrations and Operating Companies are advised to organise radio broadcast networks and to adjust repeaters on the circuit of these networks so that, when a voltage V is applied to the input of a section of any line, the same voltage V is obtained at the input of all the following sections for all frequencies transmitted, whatever be the impedance of the different sections of the line. The adoption of this regulation will considerably simplify the measurements carried out on the circuits as well as the maintenance of the lines in service.

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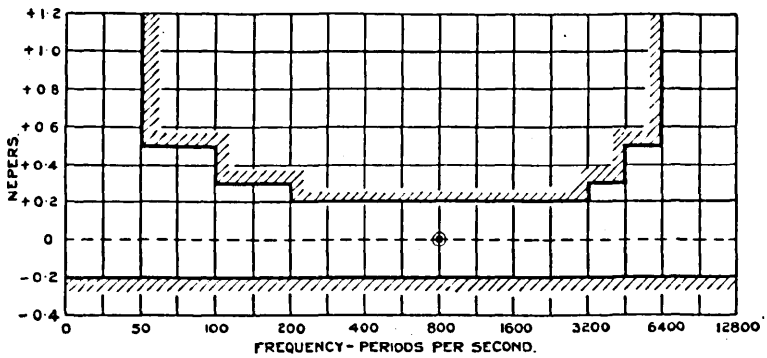
* The useful maximum voltage at a point in the circuit is the sinusoidal voltage, whose maximum amplitude corresponds to a constant maximum power of 5 mW at the point chosen for zero reference.

Similarly, the useful minimum voltage at a point in the circuit is the sinusoidal voltage, whose maximum amplitude corresponds to a power of $5 \times e^{-2 \times 1 \cdot 6}$ mW at the zero reference point.

The line connecting the studio to the beginning of the long-distance telephone circuit should be set up in such a manner that a voltage, applied at the input of this line and constant at all frequencies, produces an equal constant voltage at the input of the circuit used for relaying the radio broadcast transmission; further, the line connecting the last repeater to the transmitting station should be set up so that, under the same conditions, the voltage measured at the terminals of a resistance of 600 ohms, substituted for the transmitting station, maintains a constant value for all frequencies.

Variations in the Equivalents and Levels as a Function of the Frequency.

1. In order that transmission of speech and music may be satisfactory, the band of frequencies effectively transmitted should be 50-6400 cycles at least. For a frequency to be considered as effectively transmitted the equivalent at this frequency should be no more than 0.5 néper (4.3 decibels) greater than the equivalent at 800 cycles.*



Permissible limits for the equivalent of a telephone circuit used for relaying radio-broadcast transmission.

The permissible limits for the variation of equivalent with frequency are indicated on the attached diagram. The curve of equivalent should lie between the two limits represented by the two curves shown; these curves may be displaced by moving them together up or down, by a quantity equal to the actual value of the equivalent at 800 cycles (if this differs from zero) but less than 0.3 néper (2.6 decibels).

2. The relative level of the voltage at the output terminals of the repeater nearest to the frontier should be constant for all frequencies of the effectively transmitted band, a tolerance of ± 0.2 néper (± 2 decibels) being permitted.

In order to correct for the effect of temperature variations on equivalent, measures should be taken so that the conditions that have been imposed relating to variations of equivalent as a function of the frequency should always be fulfilled.

Note.—Automatic level indicators should, provisionally, have the following characteristics :—

(*a*) Frequency band : from 30 to 10 000 p : s.

(*b*) Law governing the relation between frequency and time :

from 0 to 100 p : s, linear function :

from 100 to 10 000 p : s, logarithmic function (*see* scale below), the functions being continuous and operating from the low to the high frequencies :—

(*c*) Emission time of one octave in the band 100–10 000 p : s, 15 seconds ; in the band 0 to 100 p : s, 21·5 seconds.

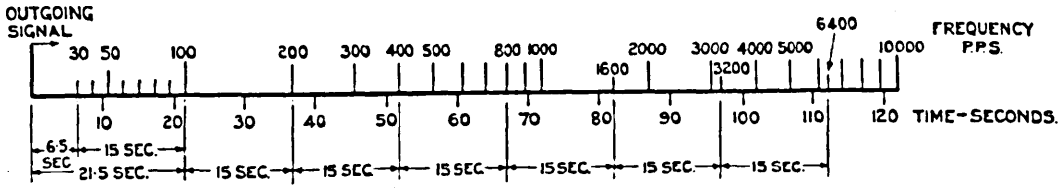
(*d*) Identification method of the frequencies at the receiving station : a signal is given by the transmitting station 6·5 seconds before the test frequencies are sent out on the line.

* Administrations and Operating Companies are reminded, that ordinary telephone circuits do not fulfil these requirements, which can only be attained by the insertion of special repeaters in the circuit.

The characteristics of this signal are :

frequency :	1300 p : s
duration :	1·5 seconds
sending voltage :	0·775 volt.

(*e*) Impedance of generator : 600 ohms ; power into 600 ohms : 1 mW.



SCALE OF FREQUENCY AND TIME
FOR AUTOMATIC LEVEL RECORDERS.

Crosstalk. Crosstalk attenuation for the voice between two lines used for relaying radio broadcast transmission, or between one of these lines and a telephone line, should be at least 9 népers or 78 decibels for cable lines and 7 népers or 60.8 decibels for open-wire lines. Where it is necessary to employ, for the relay of broadcast transmission, lines which have a crosstalk attenuation below the above values, it is necessary, in consequence, to reduce the maximum power applied at the input of these lines.

Noise. The noise voltage measured objectively* at the receiving end of the complete circuit, closed with an impedance of 600 ohms, should always be less than 1/1000th of the useful maximum voltage defined above. The ratio between the minimum value of the useful voltage and the noise voltage should always be greater than 10.

The voltage from an outside source is measured without a network filter ; as a provisional indication, this should never exceed 1/100th of the maximum useful voltage ; it is useful to measure the voltage from the outside source if one wishes to make sure that there is no danger of saturation or cross modulation.

Maximum volume : non-linear distortion. Measurements of the maximum and minimum volume ransmitted over a circuit during a broadcast relay should, for the present, be made by means of a maximum peak indicator, designed for a frequency band 30 to 7000 p : s and made in accordance with the " Characteristics recommended for volume indicators and peak indicators."

The circuits used for relaying radio broadcast transmissions should be able to transmit satisfactorily a volume variable within a range of 4.6 népers (40 decibels).

The peak voltage transmitted in the course of a radio-broadcast transmission, measured with a maximum peak indicator at any point, should not exceed the voltage which would be indicated by the same instrument at the same point, if an alternating current of 800 cycles were applied at the point of relative zero level and adjusted to deliver 5 mW.

For the maximum power and for any frequency within the band effectively transmitted the attenuation of the non-linear distortion, that is to say, the néperian logarithm of the ratio, the numerator of which is the square root of the sum of squares of the harmonics and the denominator the fundamental amplitude should be at least 2.5 népers or 20 decibels (provisional limit). Broadcasting Companies have advised that the effects of non-linear distortion are perceptible when the attenuation of this distortion is 3.2 népers or 28.8 decibels.

* *See* Part VI (Questions of protection) in this book, entitled : Apparatus for objective measurement of noise.

Transient Phenomena. Provisionally, the following maxima differences in the propagation time may be considered permissible :—

10 milliseconds between the time of propagation of the highest frequency, effectively transmitted and 800 p : s.

80 milliseconds between the time of propagation of a frequency of 50 p : s and 800 p : s.

(A.b.4.) Picture Transmission.*

Conditions relating to Picture Transmission over Telephone Circuits.

1. For the telegraphic transmission of pictures, it is only possible to use telephone circuits in which reaction coupling (singing margin) does not exceed the permissible value (*see* paragraph 4). On this basis 2-wire circuits cannot, therefore, be used in practice for the telegraphic transmission of pictures.

With normal 4-wire working, the circuit can only be used each time for one-way transmission. In this case it is generally necessary to make use of echo-suppressors, in order to eliminate coupling by reaction.

If it is desired to transmit, simultaneously, in the two directions, or if whilst transmitting in one direction it is desired to send service messages from the receiving station to the transmitting station, using the available talking circuit, it is permissible to disconnect the terminating sets and the echo-suppressors, provided the Administrations involved reach an agreement to that effect. (Additional facilities given to subscribers may be subject to a fee.)

To allow one picture transmitting station to send pictures simultaneously to several stations, it is necessary to take care that, at no point in the connections, the absolute level fall below the limits fixed for an international telephone circuit. Unless it is possible to compensate for the loss introduced by connecting intermediate picture transmission stations on a telephone circuit carrying picture transmissions by increasing the sensitivity of the receiving apparatus at the ends of the circuit, it will be necessary to insert extra repeaters at the junction points of these intermediate stations.

2. The conditions relating to the equivalent (of transmission) of 4-wire circuits used for the telegraphic transmission of pictures are, in general, the same as when used for telephony.

(*a*) Attenuation between terminating toll offices must not exceed 1.3 népers or 11 decibels.

(*b*) Attenuation between photo-telegraph offices† shall not exceed 3.3 népers or 29.0 decibels.

(*c*) The attenuation distortion between photo-telegraph exchanges shall not exceed 1.0 néper or 9 decibels in the frequency band to be transmitted for picture telegraphy. As a distortion of 1.0 néper or 9 decibels is already allowed for the telephone circuit itself, it may therefore be necessary, eventually, to compensate for the distortion of the lines connecting the photo-telegraph office to the toll exchange.

(*d*) The equivalent must remain as constant as possible during the transmission of pictures. The effect of sudden variations of 0.1 néper or 1 decibel is already apparent on the pictures transmitted. It is, besides, necessary to avoid any interruption of the circuit, however short. For this reason it is necessary to give the greatest attention to tests taken on the repeaters and lines, and to the changing over of batteries. To avoid any disturbance it is desirable that the terminating toll exchanges should be placed out of circuit when the circuit is extended to the photo-telegraph exchanges.

* This text replaces that appearing under the same title on pp. 250-252 in *Livre Jaune* (English Translation, pp. 143-144).

† By photo-telegraph office is meant any station for transmitting or receiving pictures.

Special precautions should be taken to ensure that no modulation is caused in the carrier current, either by the line or by the repeaters, even if this modulation is not audible. Such modulation can be caused, in particular, either by variations in battery voltage or by infra-acoustic telegraphy.

(*e*) The relative level (of transmission) at the outgoing side of the repeaters must be between +0.5 néper or +4.5 decibels and +1.0 néper or +5 decibels. The power of the photo-telegraph transmitter must be calculated so that the power available for the transmission of a mark is from 10 to 20 milliwatts at the outgoing side of the repeaters.

3. The difference in the times of propagation of the various photo-telegraph frequencies, and the final width of the frequency band transmitted, give rise to transient phenomena (during building up and decay) which limit the rapidity of transmission of the pictures. The frequency band chosen should be narrower—and, in consequence, the transmission speed slower—as the differences between the times of propagation in that band become greater.

The quality of the transmitted picture depends on the separating network, and on the period of the transient phenomena which vary with the transmission qualities of the lines.

The principal results of a large number of experiments obtained with a system of 5 marks per millimetre are given in the following paragraph by way of example.

Medium-loaded lines were employed up to 600 km for a transmission period of six minutes for one square decimetre, and up to 300 km for a transmission period of three minutes for 100 square centimetres. For longer cables, it is necessary to eliminate the phase distortion by means of phase compensators. Long-distance circuits with phase compensation and medium-heavy loading have already been used, with success, for photo-telegraph transmission over distances amounting to 1800 km with a transmission period of three minutes per 100 cm². Photo-telegraph transmission can also be effected, without any phase compensation, on lightly loaded cable circuits over distances amounting to 1800 km with a transmission period of three minutes per 100 cm², and 3600 km with six minutes per 100 cm².

4. The troubles arising from crosstalk, noises due to heavy currents and reaction-coupling currents, should be small enough to obtain a difference of at least 4 népers or 35 decibels between the level of the disturbing currents and the level of the photo-telegraph currents.

The stability of the circuit should be at least 2 népers or 17 decibels. If echo suppressors are used in the 4-wire circuits, a stability of 0.5 néper or 4.5 decibels will be sufficient.

5. It is desirable that circuits employed for picture transmission should be marked by a characteristic sign in the terminal exchanges and in the intermediate repeater stations, and, further, special instructions should be given to the personnel of these exchanges and of these repeater stations in order that the personnel shall not come in circuit when picture transmission is taking place.

(A.c.) Apparatus.

(A.c.1.) Subscriber's Instruments.

Tests on Subscriber's Instruments and Lines in Operation.

See "Livre Jaune," p. 252 (English Edition, p. 144). No change.

(A.c.2.) Local Exchanges.

General Conditions which should be satisfied by the new Bourse Exchanges regarding the use of International Circuits.

See "Livre Jaune," p. 254 (English Edition, p. 146). No change.

(A.c.3.) Toll Exchanges.

Comparative Advantages of Cord Circuit Repeater Positions and Terminal Repeaters, associated with Artificial Lines.

The International Consultative Committee—

Considering :—

That the use of terminal repeaters and artificial lines, automatically connected in or out of circuit, presents an important advantage over the use of cord circuit repeaters from the point of view of transmission and a certain advantage from the point of view of operation,

Unanimously advises :—

The use of terminal repeaters and artificial lines for the equipment of future international transit exchanges, whenever economical conditions will permit,

Considering, however :—

That there is actually in service a large number of cord circuit repeaters and that, in several cases, cord circuit repeaters are more economical than terminal repeaters with artificial lines,

Unanimously advises :—

That, provisionally, it is desirable to make, in each case, an economic study to determine if it is advisable to employ for a certain international transit exchange cord circuit repeaters or terminal repeaters and artificial lines.

Conditions to be satisfied by Cord Circuit Repeaters Position from the point of view of Facilities for Regulation of the Repeater, as well as for Supervision, and charging of Calls.

See " Livre Jaune," p. 257 (English Edition, p. 147). No change.

Conditions to be satisfied by International Positions as regards the type of Operator's Set and the Transmission Losses due to the Operator listening on the line.

See " Livre Jaune," p. 258 (English Edition, p. 148). No change.

Conditions which Service Observing Positions should fulfil for Telephone Traffic over International Circuits.

See " Livre Jaune," p. 259 (English Edition, p. 148). No change.

Conditions which must be fulfilled by equipment used for Conference Calls.

See " Livre Jaune," p. 260 (English Edition, p. 149). No change.

Methods of giving Toll Calls priority over Local Calls. (Blocking the Subscriber from the Toll Office.)

See " Livre Jaune," p. 261 (English Edition, p. 150). No change.

(A.c.4.) Repeater Stations.

Position of Repeater Stations.

See " Livre Jaune," p. 262 (English Edition, p. 151). No change.

Choice of Repeaters.

See " Livre Jaune," p. 262 (English Edition, p. 151). No change.

Amplification Characteristics of Repeaters.

See " Livre Jaune," p. 263 (English Edition, p. 151). No change.

Transmission Level—Adjustment of Repeaters.

The International Consultative Committee—

Unanimously advises :—

That, in order to ensure satisfactory transmission on international circuits, it is essential that the rules regarding transmission levels and adjustment of repeaters as laid down in the paragraph entitled " Maintaining satisfactory transmission " (A.e.) be observed.

The International Consultative Committee—

Considering, on the other hand :—

That appreciable variations from the normal gains of telephone repeaters inevitably occur in commercial service at each setting for various reasons, particularly due to variations in battery supply or vacuum tubes, etc.,

Unanimously advises :—

1. That it is desirable to request the attendant in charge of the repeaters to report to the supervisor at the control station the actual gains in terms of transmission units, rather than to state the position of the indicator on a particular step of the potentiometer.

2. That it is desirable to point out that the gain thus reported is the net gain of the repeater, independent of the losses due to line transformers ; the latter being included in the line losses and given on the transmission level diagram.

Compensation of the Effects due to Temperature Variations.

See " Livre Jaune," p. 264 (English Edition, p. 152). No change.

(A.d.) Lines.

See " Livre Jaune," pp. 265-304 (English Edition, pp. 152-180). No change.

(A.e.) Maintenance and Supervision of Lines and Installations.

MAINTENANCE OF GOOD TRANSMISSION.*

To ensure satisfactory co-operation between the Administrations and the Operating Companies concerned in the maintenance of international circuits and to ensure the maintenance of good transmission over international telephone circuits,

* This text replaces the one under the same title which appears on pp. 306-369 of the *Livre Jaune* (English Edition, pp. 181-220).

The C.C.I. gives below :—

(1) The principles of the methods of tests and measurements for the setting up and maintenance of international circuits.

(2) The definition of the part played by and attributes of a " control " station and " subcontrol " station.

(3) A recommendation concerning the application of the instruction (under IV) and a recommendation respecting the keeping up to date of statistics showing the average time during which circuits are not in use.

(4) Instructions relative to the essential steps to be taken for the setting up and maintenance of international telephone circuits, including information on periodic maintenance measurements and fault localisation.

I.—PRINCIPLES OF THE TESTING AND MEASURING METHODS FOR THE SETTING UP AND MAINTENANCE OF INTERNATIONAL CIRCUITS.

(*a*) Measurement of the equivalent of a telephone circuit between its two extremities.

This test is made in order to check whether the equivalent of the circuit under test corresponds to the recommendations of the C.C.I. (*see* p. 62) and to the essential clauses of a typical specification for the supply of a complete telephone cable between terminal stations inclusive of repeater stations when the cable is ordered from a single contractor responsible for the working of the whole system. (*See* p. 179.)

The principle of the measurement of the equivalent is based on the definition of the effective attenuation of part of a transmission system (*see* p. 18), and consists in applying a power, a voltage or an alternating current of known value to the input side of the circuit, which is terminated at its two extremities by impedances of known value and to measure the corresponding power, voltage or current at the other end of the circuit with respect to the values measured at the sending end.

For practical reasons and in order to give a definite meaning to the corrections which would have to be applied to the results of the measurements for the theoretical interpretation, the measurements should be carried out with the two ends of the line terminated in fixed impedances of 600 ohms.

The measurement should be made in such a manner that the whole of the sending apparatus connected to the terminals of the circuit should be equivalent to a generator of an internal impedance equal to 600 ohms generating a power of 1 mW into an external resistance of 600 ohms.

The instruments must be set up in such a manner that the test result is expressed by the exact theoretical attenuation value when the line under test is a homogeneous line having a characteristic impedance equal to 600 ohms.

The measurements will in all cases include the line repeating coil.

If the testing set fulfils the conditions given above, it will directly indicate the equivalent in transmission units.

The maintenance limits given should be expressed directly in equivalents.

A practical device for carrying out these tests is given in Appendix I hereafter entitled " Description of apparatus for making transmission measurements."

(*b*) **Transmission level measurements.**

The object of this test is to ascertain that all the repeaters in circuit work in a satisfactory manner. The test permits observation of the levels at various points of the circuit, and to determine whether they lie within the maximum and minimum values specified. These levels are fixed in the specification for the setting up of the circuits, the reference level corresponding to a power of 1 mW.

For practical measurements, the voltage levels corresponding to the power levels are determined beforehand, taking into consideration the impedances in both directions at each repeater station.

The voltage level at a point is determined by the ratio of the voltage U at this point to the voltage U_0 at the terminals of a resistance of 600 ohms consuming a power of 1 mW. The testing instruments should be so constructed that they give voltage level in transmission units.

To deduce the power level from the values of the voltage level, half the logarithm of $600/Z_n$ must be added to the latter, Z_n being the impedance at the point considered, in the direction of transmission.

At each repeater station the values of the voltage levels at the output side of the repeaters corresponding to the normal testing conditions are definitely recorded.

The information usually given upon request to the control station will only include results of tests made at the output side of the repeaters.

When the tests are made in one direction on a circuit, the gain in the other direction should, if necessary, be suppressed without changing the impedances in the direction of test. The results of the periodic tests are recorded, and make up a document giving the normal values of the different levels of the circuit under normal service conditions.

In addition to these periodic tests, the test (*b*) is also carried out to localise a fault when the transmission test between the ends of the circuit gives an equivalent which lies below the normal value by an amount exceeding the allowed tolerance, or is otherwise faulty. (*See* Instructions on establishing and maintaining international circuits, Part 2, Section A, 2d par., and Section B, 1.)

Fig. 4 in Appendix I hereafter gives a practical arrangement for carrying out this test.

(*c*) **Transmission measurements between successive repeater stations and between terminal stations and adjacent stations.**

The object of this test is to check the circuit equivalent between adjacent repeater stations, or between a terminal station and adjacent repeater stations.

The test is carried out in the same manner and with the same instruments as are used in measuring the equivalent between the ends of a circuit.

(*d*) **Measurement of the gain given by repeaters.**

(α) *At a given frequency.*

The object of this test is to check the working of the repeaters when the gain regulation is normal for service conditions.

If the gain obtained is below the value specified, tests will be carried out to check the working of the valves in question (Test j).

The output and input circuits of the apparatus used in this test should have an internal impedance, matching the impedance of the repeater.

(β) *In a band of frequencies.*

The object of this is to determine the gain frequency characteristic of a repeater.

This test consists in the determination of the gain given by a repeater when the regulation of the repeater gain is normal; it is carried out at frequencies lying in the frequency band over which the output of the repeater is satisfactory and at frequencies lying slightly above that band. The tests should be made at sufficiently small frequency intervals, the choice of the frequencies being left to the Administrations or Operating Companies, but it is recommended that a check is made of the gain with frequency as outlined in Appendix V of the "Instructions on establishing and maintaining international circuits."

The method used for this test is similar to that which is employed in test ($d\alpha$), and the impedance to be used in these tests is the same as that contemplated for test ($d\alpha$).

The input voltage must be constant at all frequencies.

(γ) *Calibration of repeaters.*

The object of this test is to check the gains of a repeater as determined by the different gain settings at a constant frequency.

It is possible in this way to be sure that the repeater works efficiently; moreover, the results obtained in this matter are used to calculate the singing point.

The method used for these tests is similar to that of test ($d\alpha$) the input power and frequency being maintained at constant values during all tests.

(*e*) Determination of the singing point of two-wire repeaters.

This test is made in a manner similar to that of test (*f*) with the exception that non-inductive resistances should be substituted for the line and balancing network. Singing should not take place in the repeater when the gain regulation on each half of the repeater is set at maximum gain.

(*f*) Determination of the singing points of a repeater in a circuit.

The object of this test is to ensure that no appreciable variation has taken place between the circuit and its balance. In order to simplify the text contained in this paragraph only terminal stations and stations which contain one repeater in the circuit are considered.

To make these tests, it is necessary to ask the two repeater stations, *E* and *W*, to close the circuit to be tested through an impedance approximately equal to that of the circuit. This condition will be realised at the terminal station by means of a rheostat of the required value, unless a suitable impedance is provided for this purpose.

At adjacent repeater stations it is better to make use of a repeater as terminating impedance. For this purpose the repeater in the adjacent station, at which the line terminates, is left in operating condition, the input and output impedances of the repeater remaining the same, but used with its potentiometer set to zero in the direction towards which the balance is to be checked.

If it is required to determine the singing point of a circuit in the *E* direction, a short-circuiting plug should be inserted in the line jack in the *W* direction and an open-circuit plug inserted in the network

jack in the *W* direction. This converts the differential transformer in the West side to an inter-valve transformer, and the unit gives the gain of a two-way 2-valve repeater. The two potentiometers which regulate the gain will be operated simultaneously until singing commences, which will be observed when listening on the monitoring circuit. The gain will then be reduced step by step alternatively on the two potentiometers until singing ceases. This test shall be repeated with the positions of the short-circuiting and open circuit plugs interchanged. The singing point is then given by the sum of the gains corresponding to the positions of the potentiometers for whichever of the two tests gives the lower value. To this number 0.7 néper or 6 decibels should be added to allow for the fact that the West three winding transformer acts as a simple intervalve transformer between the successive tubes. (*See* Appendix III, p. 105.)

The gains given by the sum of the potentiometer readings should be obtained from the results of repeater calibration tests *d* (γ).

Where a special repeater unit is provided for this test a key is substituted for the plugs, but otherwise the method of test is exactly similar.

A second method described below can be used.

The circuit and the corresponding balancing network in one direction are normally connected to the corresponding terminals of the repeater. The circuit and the balancing network in the other direction are replaced by two resistances, one of which has a fixed value (1000 ohms) and the other a variable resistance R. The gains of the two repeaters are adjusted to maximum value. The variable resistance R is decreased until the repeater sings continuously. The limiting value of the relation $\frac{R}{1000}$ obtained in this manner, bears a definite relation to the maximum possible gain. It is therefore possible to graduate the variable resistance *R* directly in transmission units.

The results of the tests made at the time of the setting up of the circuit should be kept; and the variation from these figures on subsequent tests should not exceed 0.2 néper or 2 decibels.

In case this value is exceeded the impedance of the line and balancing network should be measured.

Note.—Repeater stations should be equipped with instruments indicating rapidly and accurately whether the singing of a repeater under service conditions is due to insufficient agreement between the line impedance and balancing network. To check this, tests with instruments called " Echomesser," which is described by R. Feldtkeller and H. Jacoby in an article of the " T.F.T." (March, 1928) (*see* Appendix II hereafter, entitled " Definition and Test of the Singing Point "), or an apparatus called " Singing Point Test Set," described in an appendix presented by the British Administration (*see* Appendix III, hereafter, entitled " Measurement of the Impedance Unbalance "), could be made.

(*g*) Determination of stability.

(α) *Of a two-wire circuit equipped with several repeaters.*

The stability (stabilité—Pfeifsicherheit) of two-wire circuits is determined in the following manner:

Let the equivalent for which singing in a circuit will cease be called singing equivalent, the operators at the terminal exchanges being in circuit.

The operators at the terminal stations being in circuit, it is made to sing by gradually increasing the gains in each direction of one or more repeaters. It is recommended to increase or to decrease first the gains of the repeaters in the middle of the circuit, as these repeaters contribute most to singing. The gain is then decreased progressively until the singing ceases.

Transmission in one direction is suppressed, the equivalent in the other direction at a frequency of 800 p : s is measured and the equivalent e_1 is obtained; similarly e_2 is obtained for the other direction. If e is the average of the equivalents in the two directions under normal working conditions the stability δ is given by :—

$$\delta = e - \frac{e_1 + e_2}{2}$$

The stability of a two-wire circuit must not be less than 0.4 néper or 3.4 decibels.

(β) *Of a four-wire circuit.*

The stability of a four-wire circuit is determined by increasing the gains of one or more repeaters simultaneously in the two directions until singing ceases. After suppressing the transmission in one direction which is not necessary for circuits equipped with echo suppressors, the equivalent is measured in the other direction and *vice versa*. The stability δ is calculated from the results e_1 and e_2 of the tests in accordance with paragraph (*b*). It is recommended to determine the stability under service conditions of the terminal stations, the operators being in circuit. The stability of the circuit should not be less than 0.5 néper or 4.5 decibels.

(γ) Where the circuit is composed of two and four-wire circuits, the method and the figure given for the two-wire circuits applies.

General Notes on α, β, γ. The stability of a circuit under operating conditions should be such that, with or without the plugs in the circuit jacks at the terminal stations, the circuit should not sing, regardless of whether or no the operators are in the circuit. The repeater stations should verify whether or not singing takes place under the circumstances.

(*b*) **Impedance Measurement of Circuits.**

This test consists in measuring the impedance of circuits over the band of frequencies which are transmitted in an efficient manner by the repeaters. Its object is to know if the impedances of the circuits have undergone changes liable to influence the accuracy of balance of the repeater or introduces reflections.

The impedances should be measured by means of any well-known alternating current testing method. The ends of the circuit tested should be terminated by an impedance approximately equal to the characteristic impedance of the circuit. The tests should be made according to circumstances with or without repeating coils normally connected in the circuit considered, and at sufficiently small frequency intervals. The power applied to the line should be constant, as much as possible, over the band of frequencies to be transmitted, and should normally be 1 mW; in special cases a larger constant power not exceeding approx. 10 mW is permissible. The test results for each frequency of the two components of the impedance, *i.e.*, resistance and reactance (positive or negative) should be expressed in ohms.

(*i*) **Checking of the Accuracy of the Battery Voltages and Current Intensities.**

The object of this test is to ensure that the battery voltages remain within the limits so that the gain of the repeaters does not vary beyond the permissible limits.

(*j*) **Valve Rejection Test.**

The object of this test is to ascertain whether a fault in a repeater indicated by gain measurements is due to a change in the characteristics of the valve. It consists in the following operations :—

A suitable fixed voltage is applied to the input of the repeater in each case, for each type of repeater and valve employed. Limiting values of plate battery voltages and filament voltages are then applied, and the gain corresponding to the required value is then verified (which is also specified in advance for

each type of apparatus) and also whether any apparent variation of the continuous plate current occurs, *i.e.*, whether any such variation is detected. If these conditions are not fulfilled the valve should be rejected.

(*k*) Definition and Measurement of Crosstalk.

The crosstalk between two circuits is defined by comparing the impedance network and the connections which join the incoming terminals of the disturbing circuit to the outgoing terminals of the disturbed circuit with an heterogeneous transmission line having the same output of energy and characteristic terminal impedances Z_1 Z_2 equal respectively to the real impedance of the disturbing circuit, regarded from the side of its incoming terminals and to that of the disturbed circuit, regarded from the side of its outgoing terminals.

The intensity of the crosstalk corresponding to a given frequency is measured by the attenuation of the equivalent line (expressed in népers or decibels).

When the two terminal impedances Z_1 and Z_2 are equal to one another and to the impedance R to which the disturbed circuit is looped, the exponential e^{-b} is equal to the ratio of the induced current intensity i in the disturbed circuit to the current intensity I in the disturbing circuit. The measurement of the crosstalk then reduces itself to a direct measurement of this ratio. When these conditions are not fulfilled the true value of the crosstalk is deduced from the direct measurement of i/I or of the ratio i to applied voltage U by one or other of the following formulæ :—

$$e^{-b} = \left|\frac{i}{I}\right| \cdot \left|\frac{R+Z_2}{2}\right| \cdot \left|\frac{1}{\sqrt{Z_1 Z_2}}\right| = \left|\frac{i}{U}\right| \cdot \left|\frac{R+Z_2}{2}\right| \times \sqrt{\left|\frac{Z_1}{Z_2}\right|}$$

To carry out the actual test the ends of the disturbing and disturbed circuits, other than those used for supplying current and for listening, will be closed by the corresponding characteristic impedance. The disturbing circuit and a potentiometer, artificial line, or any other apparatus making it possible to reduce the alternating power within known proportions (the latter being arranged in series or in parallel with the line or replaced by the latter), will be fed from the same generator. The same telephone receiver will be shunted successively to the end of the disturbed circuit and to the apparatus already described, which will be adjusted to give equality of sound, *i.e.*, balance of current in the two listening positions.

The value of ratio i/I in the series arrangement, or of the ratio i/U in the parallel arrangement, will be obtained from the adjustment of the attenuator, and the value of e^{-b} will then be obtained by calculation for every case.

Finally it will be convenient to match the impedances Z_1, Z_2 and R one with the other by means of appropriate transformers, provided that these have a sufficiently high output and are sufficiently well balanced in order not to modify the results of measurements.

When voice tests are made, similar methods and correcting formulæ as indicated above will be admitted by agreement, the value of the crosstalk being deduced from the readings shown by the instruments in the same manner as if balance of sound had been obtained with a pure note. The elements intervening in the measurement, and which incorporate matching, will then be corrected to a frequency of 800 p : s (or to a frequency of $\omega = 5000$).

Far End Crosstalk Tests.

The method of measuring far end crosstalk is as follows:—

(*See*, for example, the circuit below.)

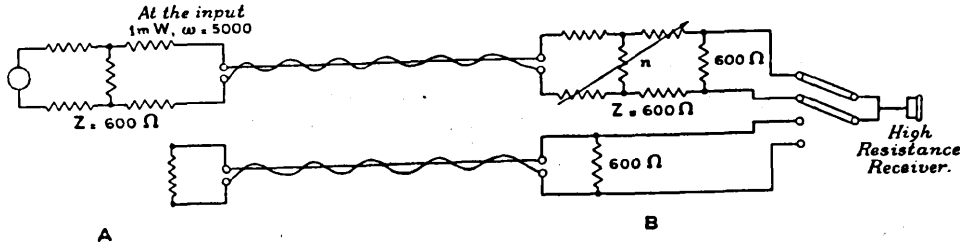
The crosstalk at the receiving end is considered to be equal to $n+n^1$, where n^1 is the total attenuation of the line and n is the attenuation of the variable artificial line, when the volume of sound in the telephone receiver is the same for the two positions of the switch.

Near end crosstalk is measured in the same way, the receiver, artificial line and switch being at the same end of the circuit.

(*l*) Interference Measurements on Telephone Circuits.

The object of this test is to obtain a measure of the interference on telephone circuits in terms of a certain well-defined system of units. The International Consultative Committee is of the opinion that the choice of the method to be employed for this test must be left over until the researches still to be made in this direction have given definite results.

Provisionally two methods are used which are described in the pamphlet published by the C.C.I. entitled "Guiding Principles concerning Steps to be taken for the Protection of International Telephone Lines against the Disturbing Influences of Heavy Current or High Tension Power Lines." (Page 7 of 1930 Edition.)



APPENDIX I.

Description of Apparatus for making Transmission Measurements.

The description below shows a typical device for making the transmission tests referred to above (pp. 91, 93). At the end of this description will be found circuit diagrams of special instruments used in different countries to measure the overall transmission equivalent of a telephone circuit between test boards in the central offices.

Fig. 1 shows the general arrangement of the apparatus. An oscillator G producing currents of audible frequencies is connected through a regulating resistance P, a screened and balanced transformer T and a milliammeter A to a section of artificial cable C_2. The functions of this cable are: (1) to make the impedance of the sending end approximately equal to that of the line; (2) to reduce the current in some convenient ratio so that the milliammeter A may measure a current larger than that entering the line under test. By this means it is possible to use a robust type of instrument for measuring the current and at the same time obtain more accurate measurements of the current entering the line under test than would be the case if the latter current were measured directly. A convenient ratio of reduction is found to be 5 to 1.

A switch S provides for the connection of the oscillator and measuring instrument to one extremity of an artificial cable C_1, or, alternatively, to one extremity of the circuit under test.

Each circuit is normally closed through a resistance Z_0 approximately equal to the characteristic impedance, of the line. The voltmeter should be of the recognised thermionic valve type, having an impedance, high compared with that of the line. Connection is made to the line under test by means of the jacks shown.

Fig. 2 shows the method of applying this set to " Gain " measurement.

The telephone repeater R is connected between fixed sections of artificial cable. The two ends of the circuit thus formed are connected by means of plugs to the " send " and " receive " jacks respectively.

The current entering the circuit is adjusted to a suitable value. The length of the cable C_1 is adjusted until the deflection on the voltmeter is the same in either position of the switch.

The transmission equivalent of the circuit consisting of the repeater R and the sections of artificial cable is then equal to the indicated length of the cable C_1. The gain of the repeater is then easily deduced.

Fig. 3 shows the application of the apparatus to overall measurements. At the sending end the switch is left in the position shown, and the current adjusted to an agreed value.

At the receiving end the line under test is connected to the " receive " jack. The current into the artificial cable C_2 is adjusted to the same agreed value as that at the sending end. A balance is then made as before by manipulating the switch and adjusting the length of the cable C_1. The resultant length of C_1 then indicates the transmission equivalent of the circuit under test.

Fig. 4 shows the application of the apparatus to " transmission level " measurements. The sending and receiving ends are similar to Fig. 3 and the measurements are made in the same way.

At intermediate stations the line is connected to the " intermediate " jack as shown. A balance is made in the same way as at the receiving station. The indicated value of the cable C_1 then gives the " transmission level " required.

The voltage corresponding to this " transmission level " may be greater than that at the sending end. To provide for this condition cable C_1 is set at zero and the cable C_2 is made adjustable and is so calibrated that it indicates directly the transmission units (or absolute units) by which the transmission level exceeds that at the sending end of the circuit.

It will be understood from the above description that it is essential that all circuits should be brought to approximately the same impedance in order that this system of measurement should give accurate results.

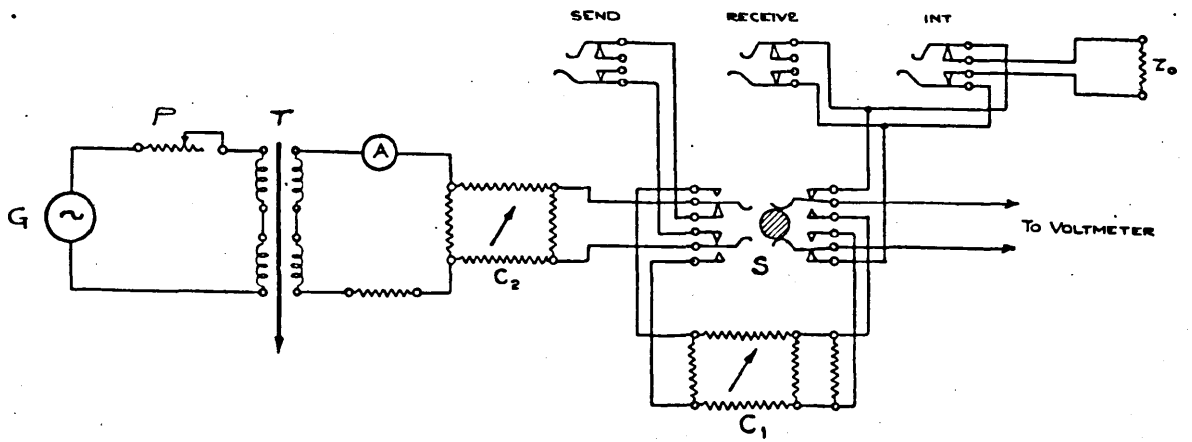


FIG. 1.

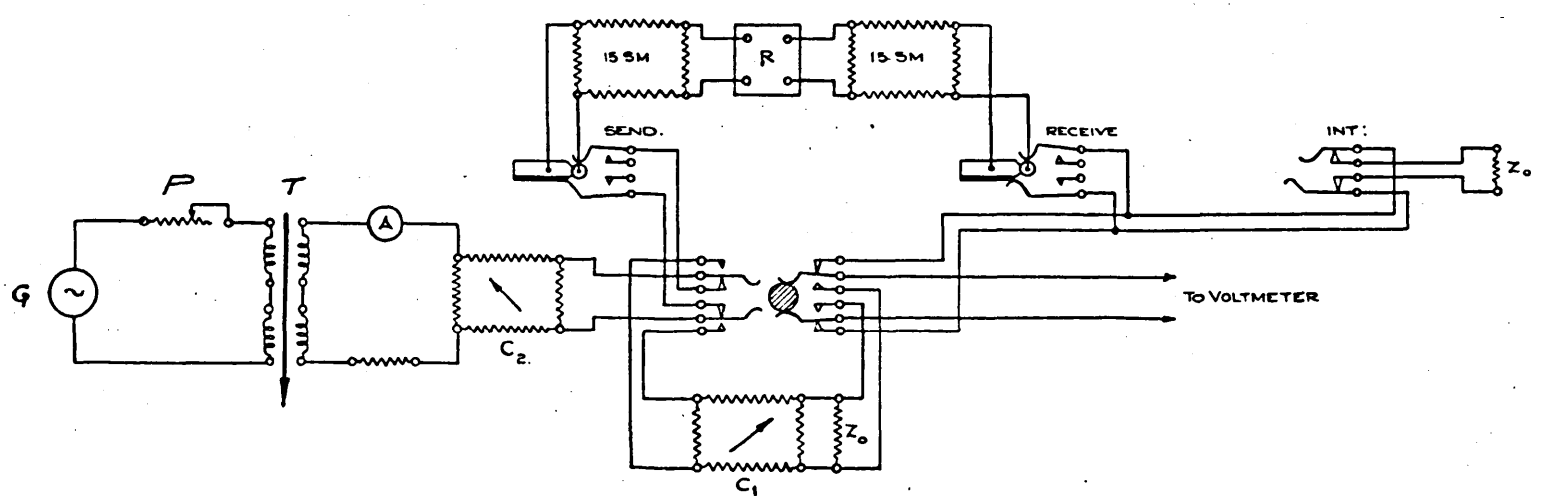


FIG. 2.—Gain Measurement.

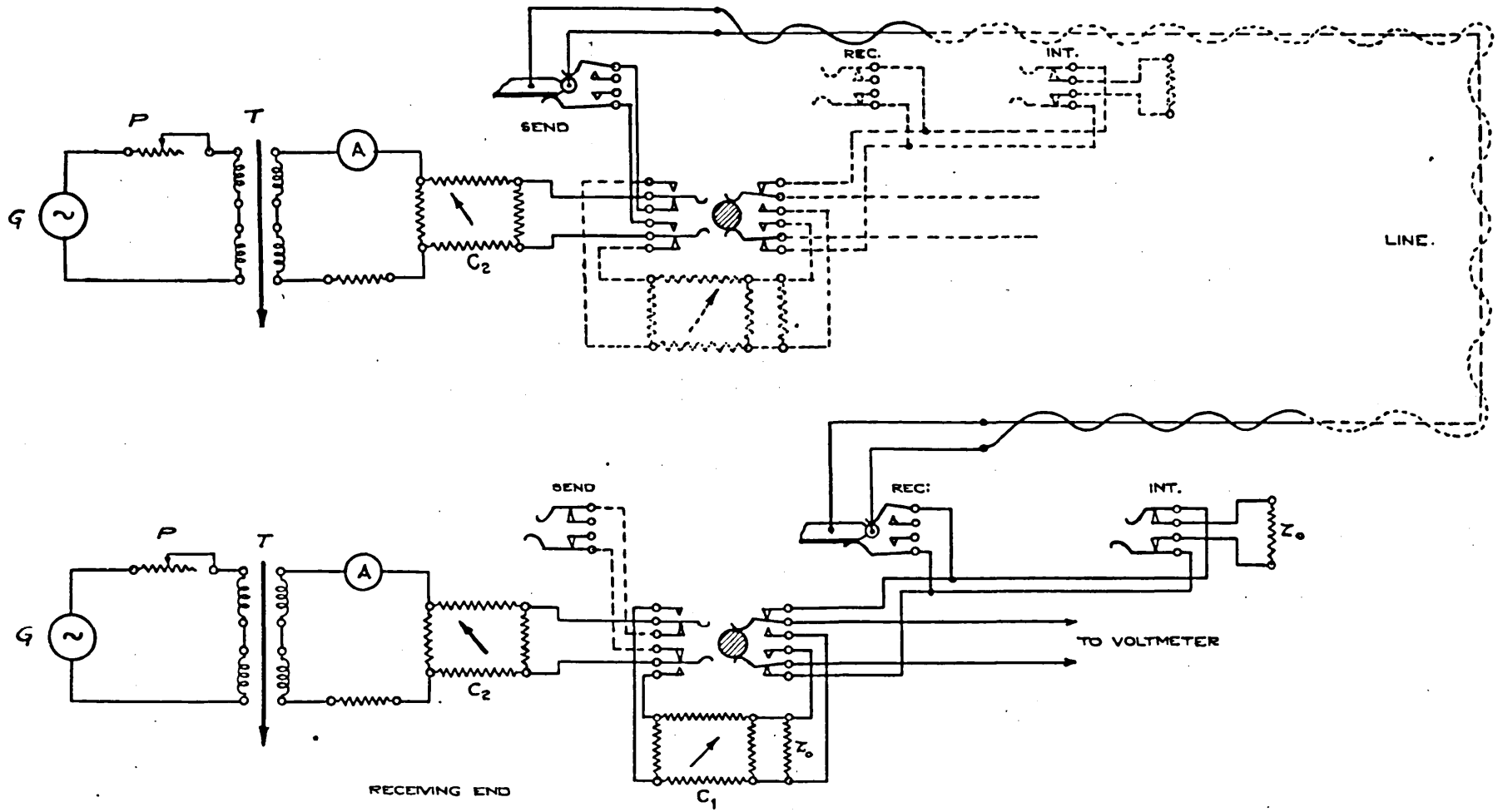


FIG. 3.—Overall Transmission Measurement.

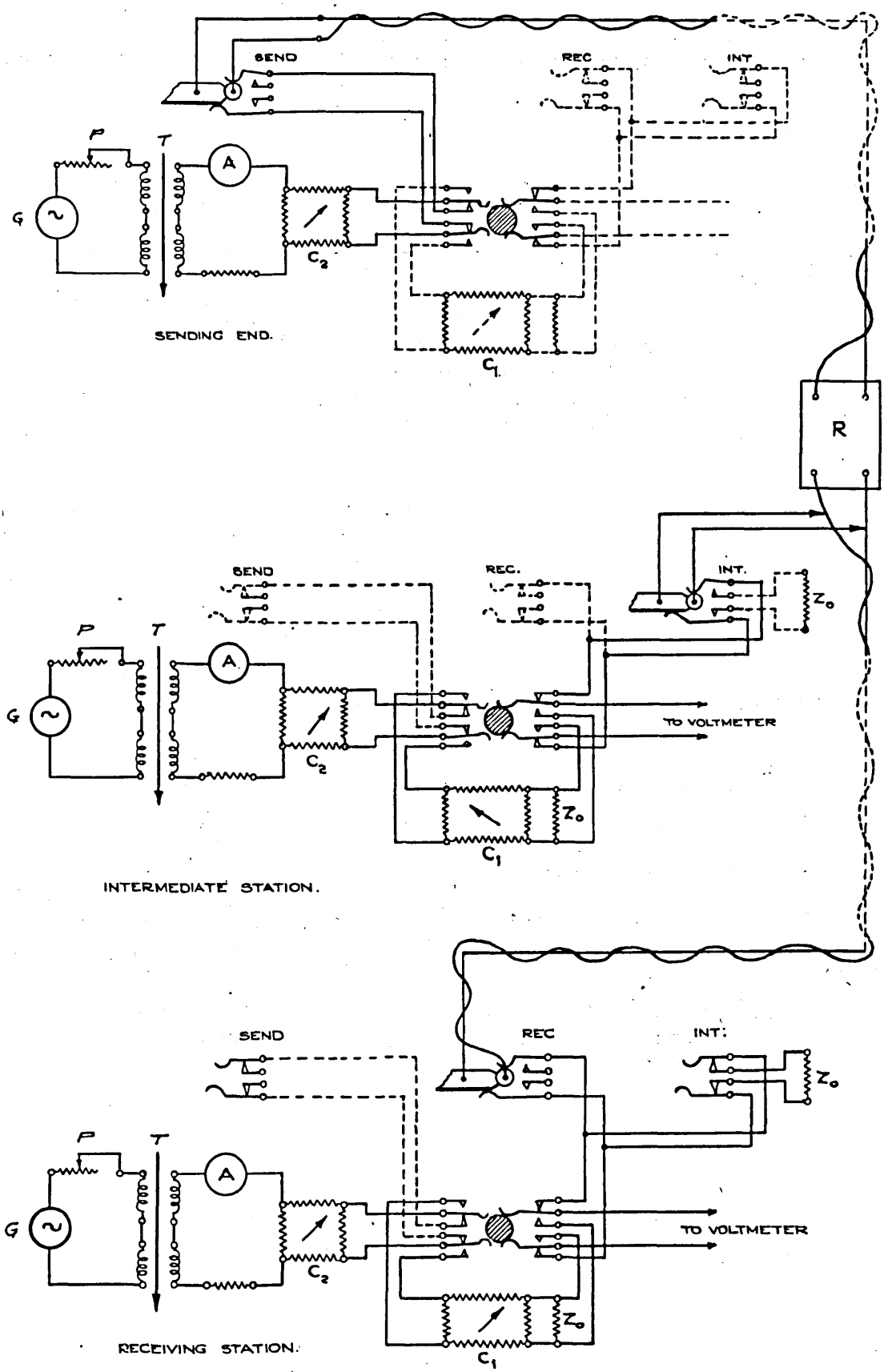
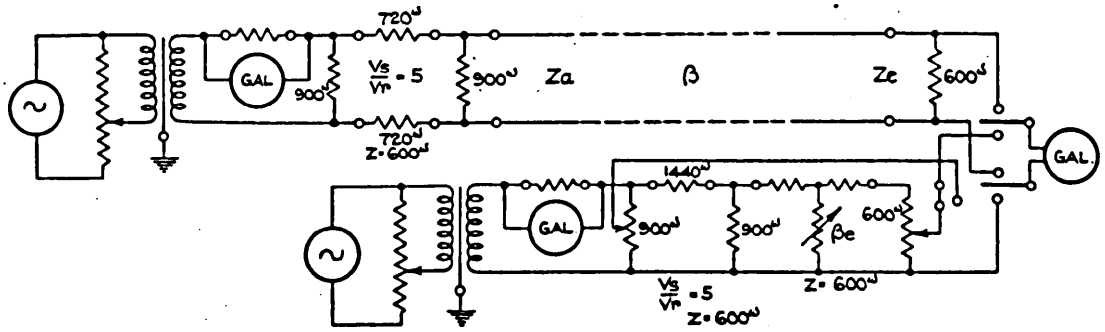


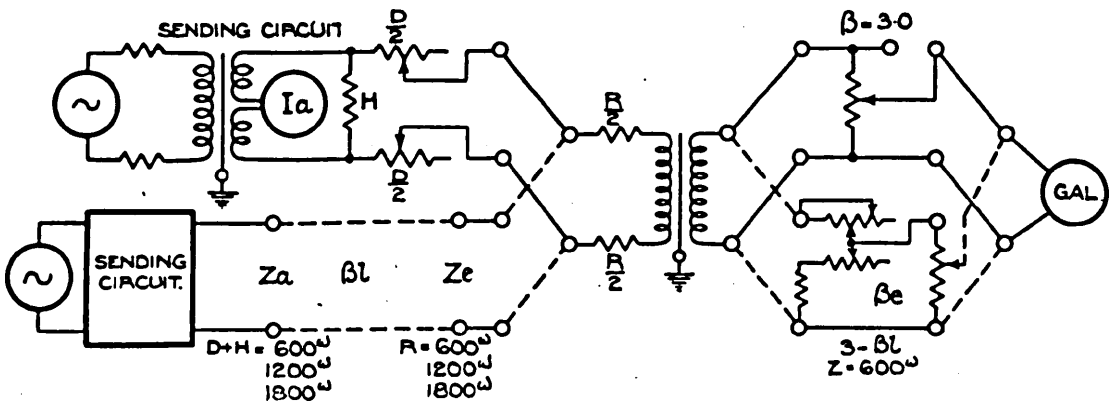
FIG. 4.—Transmission Level Measurement.

Various Special Instruments used for Measuring Overall Transmission between two Offices.

(1) *Method used by the British Post Office.*



(2) *Method used by the International Standard Electric Corporation.*



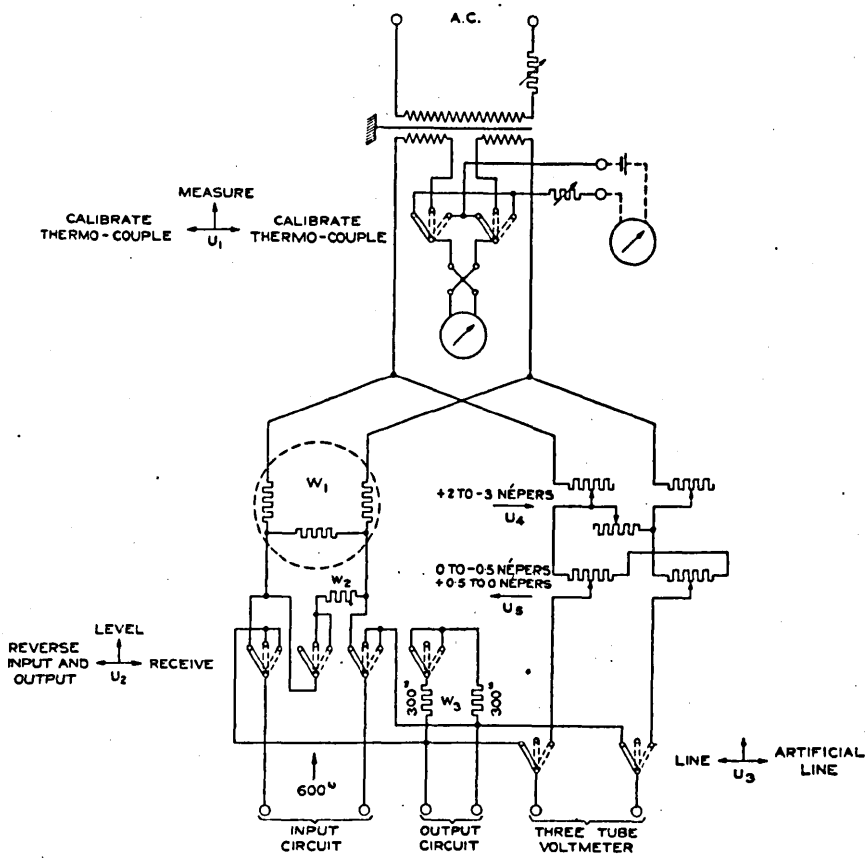


FIG. 3.—Method of the German Administration and Messrs. Siemens & Halske.

APPENDIX II.

DEFINITION AND MEASUREMENT OF ATTENUATION DUE TO ECHO (SINGING POINT).

1. The attenuation b_E due to echo (or "Singing Point") of a two-wire circuit is defined as one-half of the natural logarithm of the input power N_1, sent into the line from an adjustable generator, before the return of the echo, divided by the power of the reflected currents (power of the echo) N_2—produced by line irregularities and returning to the generator.

$$b_E = \tfrac{1}{2} \log_e \frac{N_1}{N_2} \quad \ldots\ldots(1)$$

2. A simple relation exists between the singing point b_E, the impedance Z_E of a line free from echoes, and line impedance U when echoes are present.

When a generator having an e.m.f. E_0 and an internal impedance Z is connected, for example, to the sending end of the line, the power taken by the line before the arrival of the echo is

$$N_1 = \frac{E_0^2}{4Z} \quad \ldots\ldots(2)$$

After the echo has arrived, the impedance of the line changes from Z to U so that the received current, instead of the value

$$J_1 = \frac{E_0}{2Z} \quad \ldots\ldots(3)$$

has the value

$$J_2 = \frac{E_0}{Z+U} \quad \ldots\ldots(4)$$

The reflected current corresponds to the difference between the two currents :—

$$J = J_2 - J_1 = \frac{E_0}{2Z}\left(\frac{Z-U}{Z+U}\right) \quad \ldots\ldots(5)$$

The power of the echo is therefore :—

$$N_2 = \frac{E_0^2}{4Z}\left|\frac{Z-U}{Z+U}\right|^2 \quad \ldots\ldots(6)$$

From the equation giving the singing point b_E, this is related to the impedance by the expression :—

$$b_E = \log_e \left|\frac{Z+U}{Z-U}\right| \quad \ldots\ldots(7)$$

3. Supposing that, in an ideally balanced line (Fig. 1), the line with echo is reproduced by a line free from echoes :

It is then possible to separate the ingoing line current from that which returns as echo. The loss between terminals 1 and 2 is obtained from the line impedance U, with echo, and the line impedance Z, without echo, from the formula :—

$$b_{1\longrightarrow 2} = \log_e \left|\frac{Z+U}{Z-U}\right| + \log_e 2 \quad \ldots\ldots(8)$$

or, conforming to equation (7)

$$b_{1\longrightarrow 2} = \log b_E + \log_e 2 \quad \ldots\ldots(9)$$

The characteristic impedance of the line free from echoes can be represented approximately by a balancing network. This simulation must be sufficiently exact in order that the error arising from simulating the line impedance by the network impedance is negligible as compared with the singing point.

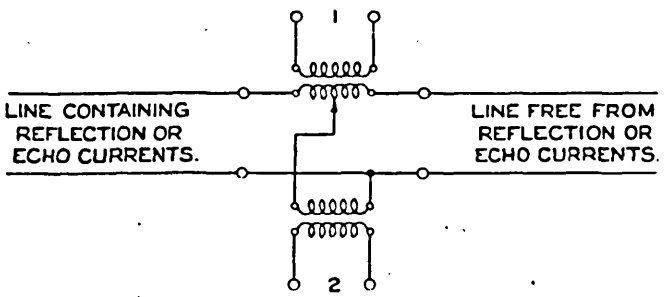


FIG. 1.—Balanced Circuit.

5. The stability of a circuit with terminating sets depends not only on the singing point b_E of the line but also on the accuracy with which the impedance U of the network simulates the characteristic impedance of the line free from echoes. In the case of imperfect simulation (with Hoyt's balancing networks for loaded circuits to within 2—3 per cent. approximately) a line free from echoes can also give rise to loss between the terminals 1 and 2 of the hybrid coil. The singing point of the line appears then to be reduced by a certain value which depends on the accuracy of simulation of the balancing network employed. The value so obtained will be designated by the effective singing point as it represents an important measure of service conditions of communication.

6. *Method of Measurement.*—Principle of the Echometer (*see* Fig. 2). The Echometer is made up of a terminating circuit, one side of which is connected to the line to be tested, and the other to the balancing network of that line, together with a repeater giving a constant amplification capable of accurate regulation between the limits of 300 and 2000 or 2400 p : s. The repeater is inserted between the

terminals 1 and 2 of the hybrid coil (terminating circuit). The attenuation between these two points being $b_E+\log_e 2$ (*see* equation 9), singing will begin when the echo attenuation equals $b_E+\log_e 2$.

The repeater comprises two normal valves connected in series, transformer-coupled; an arrangement generally used in telephone repeaters.

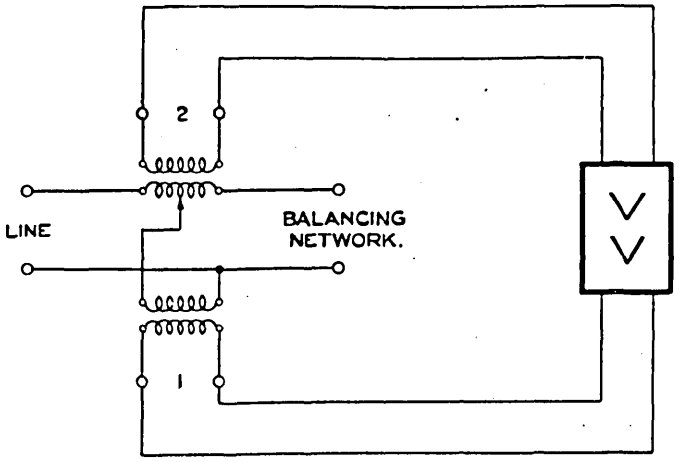


FIG. 2.—Echometer.

To obtain a high amplification within the frequency range between 300 and 2000 p : s, and a flat gain-frequency characteristic, a multiple-stage band filter is inserted. This filter gives, in addition, the advantage that the phase of the reaction circuit varies considerably with the frequency, the result being that oscillations will also be set up at frequencies where the reaction currents are in phase.

The gain-frequency characteristic can be displaced by a potentiometer calibrated in steps of 0.1 néper; the amplification can thus be regulated between the limits of singing point of 0.5 and 4.5 népers.

The echometer can be calibrated accurately, by substituting for the line and balancing network connected to the measuring bridge two resistances whose difference corresponds to a known singing point, say 3.0 népers. By means of a special rheostat which is employed only for actual tests, the gain is varied until the echometer reaches the oscillation limit for this load on the bridge.

When carrying out these tests the gain is gradually increased, starting at the lowest stop of the echometer, until continuous oscillations begin (or stop). The singing point can then be read off directly from the rheostat scale.

The repeater can be calibrated by substituting for the line and its network two resistances whose difference corresponds to a known singing point as, for instance, 3.0 népers.

APPENDIX III.

THE MEASUREMENT OF IMPEDANCE UNBALANCE.

Note by the International Standard Electric Corporation (June, 1929).

The text of this Appendix will be found on pp. 326-346 of "Livre Jaune" (English Edition, pp. 194-206). As there is no modification in that text, it is not reproduced here.

II. FUNCTIONS AND DUTIES OF THE CONTROL STATION (" STATION DIRECTRICE ") AND THE SUB-CONTROL STATION (" STATION SOUS-DIRECTRICE.")

The International Consultative Committee—

Considering :—

That in so far as concerns the maintenance of international circuits it seems necessary to set out clearly and to standardise :—

(*a*) The question of the organisation for each circuit ;

(*b*) The method of making routine tests designed to allow the rapid location of faults ;

and to recommend general rules, based on what appears to be best in present-day practice,

Unanimously advises :—

One of the stations through which a circuit passes is responsible for satisfactory transmission on that circuit. This station is called the Control Station ; it is chosen by agreement between the technical departments (Services Techniques—S.T.) of the Administrations involved. Unless otherwise arranged between the technical departments interested, the Control Station will be one of the terminal stations of the circuit.

The Control Station has the following duties :—

(*a*) To be responsible for the performance of the maintenance tests according to the rules and on the dates fixed by agreement between the different technical departments, and to reduce as much as possible the time of interruption of commercial service on the circuit.

(*b*) To cause the stations concerned to take action when the circuit develops a fault ; to carry out the various tests or investigations in such a way as to lead with the requisite speed, either to the temporary replacement of the equipment or the line concerned, or to the clearing of the fault.

(*c*) To cause repeater gains to be adjusted, in accordance with orders received from the technical departments, in such a way as to maintain the circuit at the prescribed equivalent. To enter in a log book all unusual occurrences, the time at which faults occur, exact localisation, orders given, and time at which circuit is put back into service.

However, in order to increase the flexibility of the organisation and the speed with which faults may be cleared, the Control Station may require a Sub-Control Station in foreign territory to take action ; this Sub-Control Station will have, within its territory, the responsibilities described above for the Control Station ; in particular the Sub-Control Station will be required to see that the prescribed difference in level is maintained between the frontier stations or, where the circuit terminates in its territory, between the frontier and terminal stations.

The following procedure is recommended where a circuit is affected by faults which are indicated by unsatisfactory transmission of voice or signalling currents or in an abnormal value of transmission equivalent.

1. The apparatus at terminal stations should be tested.

2. If the terminal apparatus is not the cause of the fault the levels at the frontier stations should be measured in order to find out in which territory the fault has occurred.

3. The faults in each territory should be cleared separately ; each Sub-control Station should take the required steps without delay, and may consider all faults cleared as soon as the prescribed difference in level is obtained between its frontier stations or between the frontier and terminal stations.

4. If faults are localised in a section of cable which crosses a frontier the two frontier stations concerned should give every assistance and advise their respective Sub-control Stations as soon as the faults are cleared.

5. The terminal stations and the Control Station (where this is not also a terminal station) should stand by on the circuit as soon as the faults on their territory have been cleared.

6. If a Sub-control Station clears a fault in its territory it should make a call on the circuit from time to time until a reply is obtained from the Control Station.

7. As soon as all Sub-control Stations have reported that the faults have been cleared the Control Station should cause all-over tests to be made.

III. RECOMMENDATIONS CONCERNING THE APPLICATION OF THE INSTRUCTIONS FOR THE SETTING UP AND MAINTENANCE OF INTERNATIONAL CIRCUITS.

Application of Instruction and usual phrases to be used.

The International Consultative Committee—

Considering :—

That difficulties have been observed in the maintenance of international circuits because certain Administrations did not wholly observe the instructions of the C.C.I. for the setting up and maintenance of international circuits.

That it is essential in order to ensure a regular international telephone service and, in particular, in order to ensure satisfactory working of the European telephone network, that all the different Administrations or Operating Companies use the same methods for the putting into service and maintaining of international circuits.

Unanimously advises :—

1. That all Administrations and Operating Companies strictly apply the instructions given hereafter for the setting up and maintenance of international circuits as laid down by the C.C.I., due consideration being given to the long experience obtained by the Administrations having heavily developed telephone networks.

2. That the sentences appearing in the pamphlet published by the C.C.I. entitled " List of usual phrases to be employed in the fault-locating and measuring service and in the repeater stations for maintenance of international telephone communications," be used by the staff concerned of all Administrations and Operating Companies.

3. That a permanent sub-commission (consisting of a representative of each of the following Administrations : Germany, France, Great Britain and Holland) be entrusted to solve all urgent questions concerning the application of the recommendations of the C.C.I. for the setting up and maintenance of international circuits.

Recommendation concerning the Daily Record of the Statistics of Average Non-Utilisation of Circuits.

The International Consultative Committee—

Unanimously advises :—

That the statistics of average non-utilisation of the principal international circuits should be kept according to the information given in the " Recommendations on the setting-up and maintaining of International circuits " (Section C, § 3, p. 117).

Programme of Periodical Maintenance.

The International Consultative Committee—

Considering :—

That it is advisable to facilitate as much as possible the making of periodical measurements on international circuits and to reduce to a minimum the correspondence and negotiations which are necessary for the organisation of these measurements.

That nevertheless advantage should be taken of the frequent contacts between the control and sub-control stations of the same circuit. The chiefs of these stations are, in general, better placed than the technical departments (S.T.'s) to make such arrangements.

Unanimously advises :—

1. That it is advisable to establish and keep up to date a programme of periodical maintenance indicating simply the days (not the hours) at which the periodical maintenance measurements should be made on the principal international circuits.

2. That for keeping up to date the programme of periodical maintenance, the procedure should be as follows :—

(*a*) The days for the measurements on new international circuits, as well as changes to the days for the measurements on existing circuits, are fixed by the technical department (S.T.) in charge of the Control Station of the circuit under consideration, in accord with the other interested technical departments. If a technical department, under the authority of which is a sub-control station, judges it necessary to change the days for the measurements on an international circuit, it addresses itself to the technical department in charge of the control station, who will make the necessary arrangements.

Twice a year (1st April and 1st October) the technical department informs the General Secretary of the C.C.I. of the additions and changes to make to the " Programme of Periodical Maintenance of International Circuits," in so far as concerns the circuits of which it is in control ; the Secretary-General groups together the new information thus received and transmits it to the Administrations and Operating Companies belonging to the C.C.I.

On the occasion of the Plenary Assembly of the C.C.I., the Permanent Maintenance Sub-Commission will meet to examine the whole of the Programme of Periodical Maintenance and to discuss the questions relating to the carrying out of this programme.

(*b*) If, exceptionally, agreement cannot be reached between the technical departments in the course of the negotiations mentioned under 1, the Secretary-General of the C.C.I. should be advised and he will inform the President of the Third Commission of Assessors. The different cases will be examined during the meeting held by the Permanent Sub-Commission on the occasion of the Plenary Assembly of the C.C.I. ; at this meeting, the representatives of the interested Administrations must be invited, if they are not already represented on the Permanent Sub-Commission. The President of the Third Commission of Assessors has the right to call an extraordinary meeting of the Permanent Maintenance Sub-Commission (with, should it so happen, the representatives of the other Administrations) if the cases are particularly important or if certain difficulties frequently recur.

IV. INSTRUCTIONS FOR THE SETTING UP AND MAINTENANCE OF INTERNATIONAL CIRCUITS.

PART 1.—SETTING UP OF INTERNATIONAL CIRCUITS.

Section A.—Preliminary Exchange of Information.

1. **The Putting into Service of a New Route.**
2. **The Putting into Service of a New Circuit.**

Section B.—Arrangements, Tests and Preliminary Measurements.

1. **Four-Wire Circuits.**
2. **Two-Wire Circuits.**

Section C.—Final Measurements and Tests on Complete Circuits.

PART 2.—FINAL DOCUMENTS AND MAINTENANCE.

Section A.—Forwarding of Final Documents.

1. **Regarding a Four-Wire Circuit.**
2. **Regarding a Two-Wire Circuit.**

Section B.—Organisation of Periodic Tests and of Maintenance Measurements to be made in order to ensure satisfactory Working of Circuits.

1. General.
2. Recommendations to be observed to prevent, as much as possible, interference with traffic when Periodic Tests are made:
   (*a*) *In tests made on complete circuits.*
   (*b*) *In tests made on repeaters.*
   (*c*) *In periodic tests made on line conductors.*
3. Periodicity of Regular Measurements and Tests.
   (*a*) *At terminal stations: tests made on complete circuits.*
      (α) *Measurements of equivalents between ends; resistance and insulation tests.*
      (β) *Measurements of ringing current at voice frequency.*
      (γ) *Ringing test.*
      (δ) *Speech test.*
      (ε) *Determination of the stability of circuits.*
   (*b*) *At intermediate stations: Measurement made on complete circuits or on lines (conductors).*
      (α) *Measurement of impedance.*
      (β) *Determination of the stability of circuits.*
      (γ) *Determination of levels.*
      (δ) *Determination of the singing point or of the degree of balance.*
   (*c*) *In all repeater stations: Measurements and tests made on repeaters.*
      (α) *Checking of the supply voltages and currents.*
      (β) *Measurement of gain of repeaters.*
      (γ) *Rejection tests on vacuum tubes.*
      (δ) *Tests on signalling apparatus.*
4. Method Employed in making Periodic Measurements.
   (*a*) *Measurement of equivalents and levels.*
   (*b*) *Ringing tests.*
   (*c*) *Measurements of ringing currents at voice frequency.*
   (*d*) *Speech tests.*
   (*e*) *Determination of the stability of circuits.*
   (*f*) *Impedance measurements.*
   (*g*) *Determination of the singing point or of the quality of balance.*
   (*h*) *Checking of the supply voltages and currents.*
   (*i*) *Gain measurements on repeaters.*
   (*j*) *Rejection tests on vacuum tubes.*
   (*k*) *Tests on signalling apparatus.*

Section C.—Fault Localisation.

1. General.
2. Method of making Measurements and Tests for Localising Faults.
   (*a*) *Defective transmission.*
   (*b*) *Defective ringing.*
   (*c*) *Noisy circuit.*
   (*d*) *Singing.*
   (*e*) *Crosstalk.*
3. Statistics of Non-Utilization.

INSTRUCTIONS FOR THE SETTING UP AND MAINTENANCE OF INTERNATIONAL CIRCUITS.

PART ONE: SETTING UP OF INTERNATIONAL CIRCUITS

SECTION A: PRELIMINARY EXCHANGE OF INFORMATION.

1. The Putting into Service of a New Route.

When the Administrations have decided to put into service a new cable or a new aerial line (nappe),* the technical services (S.T.) concerned should communicate to one another the circuit assignment chart of the common frontier section (*see* Appendix 1) as well as all other documents which would appear necessary.

2. The Putting into Service of a New Circuit.

As soon as the two Administrations have decided to put into service a new circuit, they will without delay inform their respective S.T.'s in order that these S.T.'s may come to an immediate agreement with respect to the necessary technical details for the setting up of this circuit.

The different S.T.'s concerned will exchange the necessary specifications relating to this circuit in order to make the initial connections (*see* Appendix II, summary circuit specification); this exchange, normally made in writing according to the form given in Appendix II, can in urgent cases be made by telephone or telegraph, but must ultimately be confirmed in writing. The specifications to be exchanged are the following:—

Type of circuit (two or four-wire).
Pair numbers of the frontier section (*i.e.*, of the section bordering the frontier).
Station in which the frontier repeater is installed (*i.e.*, repeater installed on the circuit which is nearest to the frontier).

For a four-wire circuit: the specifications include:—
Power level at the output side of the frontier repeater, frontier side (this level being normally standardised to + 0·5 néper).
The location of echo-suppressors, if any.

For two-wire circuits: the specifications include:—
Names of all stations of the S.T. concerned having a repeater on the circuit.
Attenuation of all repeater sections inclusive of the frontier repeater section.

In addition the S.T.'s of the terminal countries will designate by agreement the control station, and the S.T. of each transit country will make known to the other S.T.'s concerned the name of the sub-control station which it chooses in its territory.

SECTION B: ARRANGEMENTS, PRELIMINARY MEASUREMENTS AND TESTS.

1. Four-Wire Circuits.

Each S.T. makes out a partly-filled-in circuit and level diagram for the territory under its jurisdiction in conformity with the specimens in Appendices III, III*a* and IV. In order to facilitate and to urge on the preparation of the different partly-filled-in level diagrams, it is arranged for the output level of frontier repeaters, frontier side, to adopt the same normal value for all circuits of the same type; in principle this value is fixed at + 0.5 néper. (Power level.)

In addition each S.T. in its territory gives the following instructions:—

That the repeater gains are of the prescribed values.

That the difference in levels between stations and exchanges at the terminal points of their part of the circuit with which it is concerned be checked over the band of frequencies to be transmitted and,

* By "nappe" is meant an aerial route (bare conductors) (abbreviation for "nappe de fils").

if necessary, adjusted to the correct values*; in particular, every endeavour should be made to regulate as much as possible the difference in levels at nominal value, relative to 800 p : s.

The frontier stations check the frontier sections.

When an S.T. has thus checked and regulated that part of the circuit with which it is concerned that part of the circuit is then ready for overall measurements.

The S.T. in charge of the control station is advised by each of the other S.T.'s as soon as their parts of the circuit are ready.

2. Two-Wire Circuits.

For all two-wire circuits the S.T.'s to which the control station reports, shall draw up a provisional circuit chart and a complete provisional level diagram in accordance with the information received from the other S.T.'s concerned. (*See* specimen in Appendices III, III*a* and IV*a*.) An extract which does not include a level diagram is posted in duplicate to these S.T.'s for checking and agreement.

To draw up a level diagram, it is recommended to proceed according to the following rules :—

The gain (s) of the various repeaters starting from the terminal station shall be determined as follows :—

Let the circuit be made up of 5 sections and the attenuation of each be respectively b_1, b_2, b_3, b_4, b_5 and e the circuit equivalent; let s_1 be the gain of the first repeater, s_2, s_3, the gains of the intermediate repeaters, s_4 the gain of the last repeater; we have then :—

$$\left(s_1 = b_1 + \frac{b_2}{2} - \frac{e}{2}\right)$$

$$\left(s_n = \tfrac{1}{2} b_n + \tfrac{1}{2} b_{(n+1)}\right) \quad (n = 2 \text{ or } 3),$$

$$\left(s_4 = b_5 + \frac{b_4}{2} - \frac{e}{2}\right)$$

The S.T.'s give, for each part which concerns them, the necessary instructions, so that the circuit may be regulated in conformity with the level chart; the best balance is then obtained for each side of the repeater. The measurements are made on each repeater by suppressing the transmission of the adjacent repeaters in the direction of the repeater under test. In the case of the terminal repeaters of the circuit the winding on the office side of the terminal line repeating coil is closed with a resistance equal to the normal characteristic impedance of the circuit as seen through the repeating coil. This is done before singing point tests are made. When each station has determined the singing point for each side of the repeater or the degree of balance for each side of the repeater, it will communicate this information to the control or sub-control station, which will then prescribe the necessary adjustments.

SECTION C: FINAL MEASUREMENTS AND TESTS ON COMPLETE CIRCUITS.

When the different parts of a circuit are ready, the control station, in conjunction with, and through the intermediary of, the sub-control stations and the different stations concerned, proceeds to a final regulation of the circuit and gives the final necessary corrections to ensure the best possible transmission. For two-wire circuits in particular the gains calculated by the rule given above must in general be modified in order to take into account the relative geographical positions of the repeaters and the different values obtained when singing points are measured.

* By correct value is understood the nominal value with permissible tolerances of the power levels at frontier stations, *i.e.*, from 600 to 1200 p : s, a tolerance of ± 0.2 néper, from 400 to 600 p : s, and from 1200 to 1600 p : s a tolerance of ± 0.3 néper, from 300 to 400 p : s and from 1600 to the higher limit of the band of frequencies to be transmitted a tolerance of ± 0.5 néper, with a reservation that under no circumstances the power level exceeds + 1.1 néper.

The equivalent of the circuit is then measured at the frequencies of 300, 500, 800, 1400 and 2000 p : s (and 2400 p : s for light loaded circuits); it is also preferable to make measurements at frequencies of 400, 600, 1000, 1200, 1600 p : s (and 2800 p : s for light loaded circuits). During these measurements the equivalent at 800 cycles is checked rapidly in order to be certain that it has not changed during the tests. Measurements are made, for instance, in the first case in the following order : 800, 300, 500, 800, 1400, 2000 (2400) 800 p : s, in the second case in the order : 800, 300, 400, 500, 600, 800, 1000, 1200, 1400, 1600, 800, 2000 (2400 and 2800) 800 p : s. The S.T.'s can come to an arrangement among themselves if necessary in order to make measurements at other frequencies than those indicated above. In addition it is recommended to make measurements at frequencies higher than the frequencies of the band to be transmitted to ensure that the equivalent at these frequencies is higher than the smallest equivalent in the band to be transmitted.

The tests are continued until the equivalent, the levels and the stability of the circuit correspond to the recommendations of the C.C.I., and until, especially in the case of four-wire circuits, the frontier stations have attained for their levels the values specified in Section B, paragraph 1 above.

PART TWO: FINAL DOCUMENTS AND MAINTENANCE

SECTION A: FORWARDING OF FINAL DOCUMENTS.

If the circuit satisfies the required conditions after being put into service the following procedure is adopted :—

1. For a four-wire Circuit.

The S.T.'s concerned exchange amongst themselves partial circuit diagrams and the partial level diagrams when these documents have been checked and completed, if necessary, according to the observations made in the course of the final adjustments.

2. For a two-wire Circuit.

The S.T.'s concerned exchange amongst themselves the partial circuit diagram. The S.T. on which the control station depends sends the complete level diagram to the other S.T.'s concerned; this diagram having been completed and checked according to final adjustments.

The forwarding of the documents mentioned (1 or 2) is made in duplicate for each S.T. concerned, one for the control station (or sub-control station), the other for the corresponding S.T.

All modifications to these documents must be the subject of an amending communication in duplicate to the S.T.'s concerned.

With respect to the future maintenance measurements, by " normal values " is understood the values obtained after final adjustments which are recorded on the diagrams.

Section B. Organisation of the Periodic Maintenance Tests and Measurements to be made in order to ensure a satisfactory Working of the Circuits.

1. General.

The S.T. on which the control station depends enters into communication with the other S.T.'s concerned in order to fix the dates and methods to be adopted for the periodic maintenance measurements. To this end it uses the programme of periodic measurements (*refer to* Appendix V).

2. Recommendations to be observed in order to prevent as far as possible Interference with Traffic when Periodic Measurements are made.

(*a*) *TESTS MADE ON COMPLETED CIRCUITS.* It is recommended to choose the hours of periodic measurements in such a manner as to minimise interference with telephone traffic. Especially is it desirable that where circuits are heavily loaded the Administrations or the Companies concerned should study the possibility of making the tests outside normal attendance hours of the technical staff. Where it is absolutely impossible to measure a circuit at hours which will not interfere with traffic, it is recommended to use as far as possible complete circuits or replacing sections. These circuit sections could include one or more repeater sections, and should be set up as well as the replacing circuits according to the instructions of the C.C.I. The replacing sections which are frequently checked could after a suitable adjustment be connected at any moment in order to replace a circuit to be withdrawn from service.

(*b*) *MEASUREMENTS TO BE MADE ON REPEATERS.* In order to prevent the gain measurements of repeaters in service from interfering with the traffic the following procedure will be adopted as far as possible :—

If a spare repeater is available the line repeater to be tested will be replaced by a suitable spare repeater, the gain of which has been approximately regulated in order to be sufficiently close to the normal gain.

If no spare repeaters are available the tests will be carried out at a time of day when a short interruption of the circuit will not interfere with the service or will not interfere with it to any great extent. This period will be determined by agreement between the exchanges and line terminal stations of the circuit.

(*c*) *PERIODIC MEASUREMENTS MADE ON LINE CONDUCTORS.*

(α) With respect to cables used simultaneously for international circuits and for national circuits the periodic measurements and tests of impedance, insulation, resistance and resistance unbalance, should not be made on lines allotted to international circuits. If it is impossible to follow this rule, lines used for international circuits will be measured or tested only after having been replaced by other suitable circuits. If this substitution is not possible the measurements and tests will not be undertaken unless the necessary notice has been given to the terminal stations.

(β) In the case of a section bordering the frontier the measurements and tests will be made according to agreed programme between the Administrations or Companies concerned; in drawing up this programme it will be necessary to take into account the necessity to interfere as little as possible with the traffic.

3. Periodicity of Regular Measurements and Tests.

(*a*) *AT TERMINAL STATIONS: MEASUREMENTS EFFECTED ON COMPLETE CIRCUITS.*

(α) *Measurements of equivalent between terminals.* The periodicity of the measurements made on circuits (in cable or aerial) including no repeaters is left to the discretion of the Administrations or Companies concerned.

Measurements made at a single frequency (800 p : s).

2-wire circuits	2-wire circuits having one repeater	Annually.
	2-wire circuits having 2 or 3 repeaters	Half yearly.
	2-wire circuits having 4 to 6 repeaters	Quarterly.
	2-wire circuits having more than 6 repeaters	Monthly.
	2-wire extra light loaded circuits	Monthly.
	2-wire circuits including an aerial line with at least one repeater	Monthly.
4-wire circuits	Circuits of less than 15 repeaters	Monthly.
	Circuits of at least 15 repeaters	Weekly.
Circuits of special constitution	4-wire circuits containing an aerial line with at least one repeater	At least once a week and according to the agreements arrived at between the Administration concerned.
	Circuits for high-frequency carrier currents	do.

4-wire and 2-wire circuits, including an open wire section without repeater, are treated as complete underground circuits.

Measurements made at different frequencies 500, 800, 1400, 2000 (2400 p : s for light loaded circuits only)

2-wire circuits	2-wire circuits having less than 4 repeaters	Annually.
	2-wire circuits having at least 4 repeaters	Half yearly.
	2-wire circuits incorporating at least one aerial section	Half yearly.
4-wire circuits		Half-yearly.
Circuits of special constitution (*see* above)		Half yearly.

(β) *Measurements of the ringing current at voice frequency.* These measurements (of current, voltage or power) are made at the same time as the measurements of equivalent. (*Refer* to the periodicity above, under *a* α).

(γ) *Signalling tests.* Signalling tests between operators of terminal exchanges and eventually (as a result of an agreement with the Administrations concerned) between end stations, will be made daily.

(δ) *Speech test.* The speech test between operators of terminal exchanges and eventually (as a result of an agreement with the Administrations concerned), between end stations, will be made daily.

(ε) Determination of the stability of circuits (*refer* to *b*, δ below).

2-wire circuits	When the equivalent between the ends of the circuits is measured at a single frequency.	
4-wire circuits	Circuits which are entirely 4-wire	Half yearly.
	4-wire circuits *incorporating* 2-wire sections	Half yearly.

(*b*) *AT INTERMEDIATE STATIONS : MEASUREMENTS MADE ON COMPLETE CIRCUITS OR LINES (CONDUCTORS).*

(α) Impedance measurements.....Annually.

(β) Determination of the stability of circuits. (*Refer* to *a* ε above).

(γ) Determination of levels. Levels at frontier repeater stations.

These are to be made at the same time as the measurements of equivalent between terminals (*refer* to *a* α above).

Levels at other stations. Only when requested by the control or sub-control station.

(δ) Determination of the singing point or of the degree of balance.

For all 2-wire circuits.....at the same time as the tests for stability of the circuit.

For circuits incorporating 2-wire sections inserted between 4-wire sections.....weekly on each end of the 2-wire section.

(c) IN ALL REPEATER STATIONS: MEASUREMENTS AND TESTS MADE ON THE REPEATERS.

(α) Checking of the supply voltages and currents.....daily.

(β) Gain measurements of repeaters.

At a fixed frequency.....weekly.

At various frequencies.....annually or half yearly. (*Refer* to *a* α above.)

(γ) Valve rejection test.....weekly in conjunction with the Test 2 (*a*) above.

(δ) Signalling tests .....monthly.

If in the course of a month measurements of equivalents should be made (*a* α) or measurements of ringing current at voice frequencies (*a* β), tests of the signalling apparatus at voice frequency should be made at the same time.

4. Method of making Periodic Measurements.

(*a*) *Measurements of equivalent and levels.* Measure the equivalent and frontier levels on each of the circuits at a frequency of 800 p : s and at frequencies indicated in Appendix V. Take note of the results. There is a fault if the results of tests at the frequency of 800 p : s deviate from the normal value (*see* Part 2, Section A-2, last paragraph) by a value greater than 0.2 néper. The normal values of the equivalent of circuits are recorded on cards in accordance with Appendix V. There is also a fault if the results deviate with frequency from the permissible limits for the variation of the equivalent or for the frontier levels.

In order to facilitate and expedite localisation of possible faults on long international circuits it is necessary during each measurement of equivalent at one or various frequencies, to measure the output levels of frontier repeaters on the frontier side. On the other repeaters the measurement of level should be made only when the control or sub-control station requests it. (For the localisation of faults *see* below Part 2, Section C.)

It is desirable :—

For circuits measured twice yearly to choose the dates of these half-yearly measurements of equivalent in such a manner that one of these measurements is made in summer and the other in winter.

For the circuits measured once a year it is advisable to choose as far as possible the spring or the autumn as the season for carrying out the measurements.

(*b*) *Signalling tests.*—Each morning when making speech tests (*see d* below) the operators of the terminal exchanges must verify that the ringing signals work satisfactorily. If the ringing signals are not received correctly it will be necessary to proceed as indicated below (Part 2, Section C. Localisation of Faults).

In any case as a result of a special agreement between the Administrations concerned these tests should be preceded by a checking of the calling apparatus between terminal stations.

(*c*) *Measurements of ringing currents at voice frequency.*—It is indispensable that in conjunction with the periodic measurements of equivalent and the tests of voice frequency ringers the Administrations and the Companies concerned proceed according to an agreement between them to check the signalling current under normal service conditions. The hypsometers could be used for this purpose.

(*d*) *Speech test.*—Each morning the operators of the terminal exchanges will proceed with speech tests on all circuits in order to ensure that these are satisfactory in every respect for commercial speech. If a fault is found, localisation tests should be carried out. However, as a result of a special agreement between the Administrations concerned these tests can be preceded by a similar test between terminal stations.

(*e*) *Determination of the stability of circuits.*—Refer to the description of the principle of these methods (p. 94) and the specifications for the supply of complete cables (p. 179).

(*f*) *Impedance measurements.*—These measurements are made, if necessary, according to the method indicated on p. 95.

(*g*) *Determination of the singing point or of the degree of balance.*—These tests should be made according to the methods indicated on p. 93.

(*h*) *Checking of the supply voltages and current intensities.*—It is necessary that the supply voltages and current intensities of all repeaters on the circuits be checked in conformity with the disposition set out on p. 95.

(*i*) *Gain measurements of repeaters.*—The gain for each direction of the repeaters in service at a frequency of 800 p : s and in the band of frequencies for which the circuit must have a satisfactory efficiency must be measured; note must be made of the results of the measurements.

(*j*) *Valve rejection tests.*—These tests must be made according to the methods indicated on p. 95.

(*k*) *Signalling tests.*—Each ringer must be checked and tested locally; the station concerned must measure the necessary voltage and current intensity necessary to work the signalling apparatus satisfactorily and record same.

SECTION C.—LOCALISATION OF FAULTS.

1. General.

The following paragraphs complete the recommendations of the C.C.I. concerning the duties and responsibility of the control station (*see* p. 106). The measurements and tests for the localisation of faults always take priority over periodic maintenance measurements or tests. As soon as a fault has been reported, and according to the circumstances, measurements or tests described below under 2, are proceeded with. If the faults appear to produce an interruption which will interfere with traffic to any great extent a provisional section or provisional circuit provided especially for this purpose should, as far as possible, be substituted for the faulty section or circuit.

For all fault localisation measurements the control and sub-control stations are responsible for the clearing of the faults in their respective territories; they must report them to the terminal stations, at the same time giving an indication of the nature of the fault and also, if possible, of its probable duration. As soon as the fault is cleared the terminal station must be advised thereof.

The terminal stations, if so requested, should collaborate in the clearing of a fault by participating in the tests in one or the other country. It is recommended that the control and sub-control stations

forward to their respective S.T.'s at fixed periods a summary of the faults on the international circuits. In cases of faults of a special character or which are very difficult to localise, or in the case where it is found that the same type of fault occurs frequently on the same circuits, the control and sub-control stations must inform their respective S.T.'s immediately; the S.T.'s in collaboration will take the necessary steps to localise or to prevent these faults in the future.

2. Method of making the Fault Localisation Measurements and Tests.

(*a*) *Defective Transmission.*—If a fault is observed when measurements of equivalent are made it is found convenient to proceed to carry out level measurements on frontier repeaters in order to determine the country in which the fault lies. The normal values of the levels are recorded on level diagrams set up according to the specimens given in Appendices IV and IV*a*. The results of these measurements should be transmitted ultimately to the competent S.T. by the control or sub-control station. The control or sub-control station must take all possible measures for the rapid clearing of the fault.

(*b*) *Defective signalling apparatus.*—Where signals are badly received the signalling apparatus must be checked locally; if its working is normal the equivalent and frontier levels must be measured at the voice frequency; the voltages and current intensities at voice frequencies must then be measured.

(*c*) *Noisy Circuits.*—If the circuit is noisy the disturbance should be localised from one of the terminal stations by cutting the various repeaters successively out of circuit. The defective section of the circuit is determined by recording whether the noise can still be heard after cutting the repeater out of circuit. To determine the country where the fault occurs the frontier repeaters are cut out of the circuit successively. Echo suppressors are also cut out.

(*d*) *Singing.*—If a 2-wire circuit sings, the singing point must be verified, or the degree of balance at each repeater in the circuit must be checked; if in a 4-wire circuit incorporating a 2-wire section, the 2-wire section sings, the singing point or the degree of balance at each end of the 2-wire section must be checked. If the singing can be stopped by slightly increasing the equivalent this should be done in order to keep the circuit in service during heavy traffic hours; the localising or the clearing of the fault should be proceeded with later as soon as traffic permits.

(*e*) *Crosstalk.*—If the crosstalk interferes with the service, crosstalk measurements described in p. 96 should be made in the first place between terminal stations. In order to determine the country in which the fault lies the tests should be repeated starting from the terminal stations successively with each of the stations where frontier repeaters are installed, and this in each direction.

3. Statistics of Non-utilisation.

The sub-control stations communicate to the control station of a certain circuit detailed information concerning all the faults which occur on the circuit. When the Operating Service indicates an abnormal duration of non-utilisation of a particular circuit connecting important transit centres, the sub-control stations and the control station prepare statistics of non-utilisation of this circuit in the form of the attached table. The statistics prepared by the sub-control stations are sent to the control station, where they are compared; if there seems to be a disagreement the control station confers with the interested sub-control stations; if the statistics agree the control station prepares a document which is sent to the technical service concerned; the S.T. sends a copy to each of the S.T.'s of the Administrations and Operating Companies interested.

APPENDIX I.

Assignment Chart of the Common Frontier Section.

Between.....*and*.....

Frontier Repeater Stations.

.....(A)

.....(B)

.....(C)

.....(D)

Pair or quad numbers.		Diameter of conductors mm	Type of loading and cut off frequency (f_0)	Type of circuit (2- or 4-wire)	Repeater stations and direction of transmission.	Frontier section equivalent (inclusive of the repeating coil losses)	Remarks.
Pairs.	Quad.						
1a	1b	2	3	4	5	6	7

APPENDIX II.

Technical Service of.....

(*name of country*)

Summary Specification

of a...wire circuit No.....between.....(A) and.....(B) for the frontier section

Control station.....

Sub-control station.....

(Rule out line not applying).

Pair or quad number		Location of frontier repeater (name of station)	4-wire circuits.					2-wire circuits.			Remarks
			Type of loading	Output power level of the frontier repeater, frontier side.		Echo Suppressors	Remarks	Type of loading	Repeater stations in the territory of the S.T.	Equivalent between repeater stations (inclusive of repeating coil losses)	
Pair	Quad			Direction A-B	Direction B-A						
1	2	3	4	5	6	7	8	9	10	11	12

APPENDIX III.

CIRCUIT CHART (*front*).

Circuit No. : 1
From (A) : Berlin.
To (B) : London
Control Station : Berlin
Put into Service : 5-11-26.

in Germany No. Fk. 9950, Control Berlin
in Holland No. Lnd. Bln. 1, Sub-control Rotterdam
in England No. Lnd. Bln. 1, Sub-control London
in..... No..... Sub-control

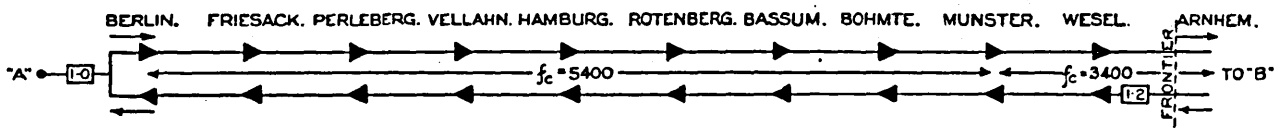
Equivalent at 800 p : s 1·0 ± 0·2 néper.
Stability : .....
(4-wire) : echo suppressor at Wesel.
Card issued 3-5-30

No.	From.	To.	Length km	Cable or Open-wire.	Dia-meter mm	Pair No.	Cut-off Fre-quency.	Average Impedance at 800 p : s		Equivalent of Section at 800 p : s including repeating coils.	Line Attenuator.			Type of Ringing Current.	Indications on the use of infra-acoustic telegraphy or simultaneous super-phantom telegraphy.	Remarks.
								Without repeating coils.	with repeating coils.		with or without distor-tion.	b. néper or db.	Z Ohms			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Berlin ...	erminal ...								0·5 0·5	without	1·0	800			
2	Berlin ...	Friesack ...	65·6		0·9	45	5 400	920	1 000	2·13				500/25		
3	Friesack ...	Perleberg ...	67·6		,,		,,	,,	,,	2·20						
4	Perleberg	Vellahn ...	74·6		,,	73	,,	,,	,,	2·41						
5	Vellahn ...	Hamburg ...	71·3		,,	101	,,	,,	,,	2·31						
6	Hamburg	Rotenburg ...	74·6	Underground Cable.	,,	135	,,	,,	,,	2·41						
7	Rotenburg	Bremen ...	45·5		,,	45	,,	,,	,,	2·42						
8	Bremen ...	Bassum ...	29·5		,,		,,	,,	,,							
9	Bassum ...	Bohmte ...	70·4		,,	73	,,	,,	,,	2·28						
10	Bohmte ...	Münster ...	77·0		,,	51	,,	,,	,,	2·49						
11	Münster ...	Dortmund ...	60·7		,,	79	3 400	1 770	960	2·63						
12	Dortmund	Mülheim ...	46·5		,,	80										
13	Mülheim	Wesel ...	36·6		,,	122								500/20		
14	Wesel ...	Arnheim ...	69·6		,,	59				1·37	with	1·2	800			
						87										

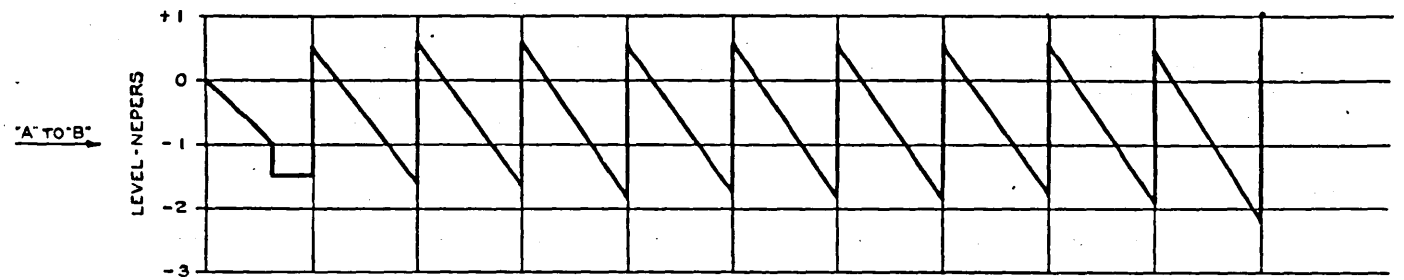
APPENDIX IIIa.

CIRCUIT CHART (*back*).

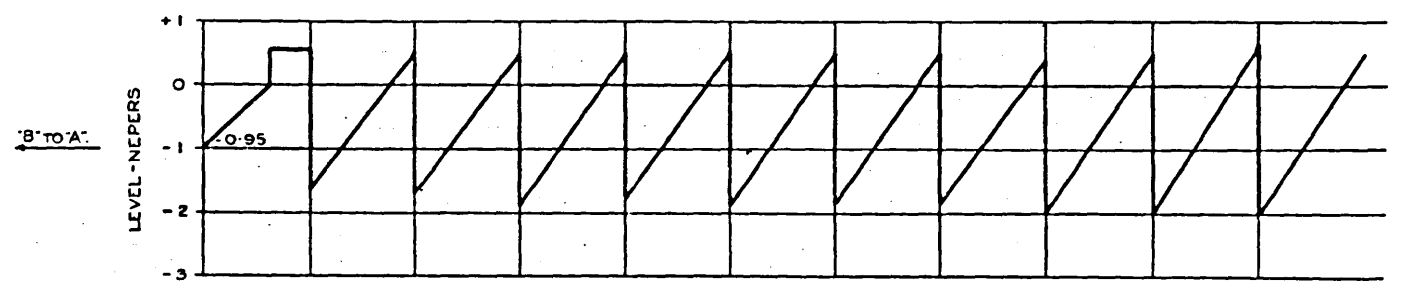
Order No.	Stations.	Type of Repeater	Adjustment of Gain.		Fixed or Adjust-able Equaliser	Direction A to B.		Direction B to A.		Singing Point.		Remarks.
			Max.	Min.		Gain at 800 p:s	Gross Level.	Gain at 800 p:s	Gross Level.	Side A.	Side B.	
1	2	3	4		5	6		7		8		9
1	Berlin ...	4 Sl.	2·5	2·0	fixed	2·0	0·7	2·2	0·75			
2	Friesack ...	,,	,,	,,	,,	2·2	0·8	2·2	0·7			
3	Perleberg ...	,,	,,	,,	,,	2·2	0·8	2·4	0·7			
4	Vellahn ...	,,	,,	,,	,,	2·4	0·8	2·3	0·7			
5	Hamburg ...	,,	,,	,,	,,	2·3	0·75	2·4	0·7			
6	Rotenburg ...	,,	,,	,,	,,	2·4	0·75	2·4	0·75			
7	Bassum ...	,,	,,	,,	,,	2·4	0·75	2·4	0·75			
8	Bohmte ...	,,	,,	,,	,,	2·3	0·75	2·4	0·65			
9	Münster ...	,,	,,	,,	,,	2·4	0·65	2·5	0·7			
10	Wesel ...	4 RhS	2·8	2·4	,,	2·68	0·7	2·7	0·8			



DISTANCE. KM.		65·6	67·6	74·6	71·3	74·6	75·0	70·4	77·0	143·8	69·6



LOSS OR GAIN. NEPERS	-1·0	-0·5	+2·0	-2·13	+2·2	-2·2	+2·2	-2·41	+2·4	-2·31	+2·3	-2·41	+2·4	-2·42	+2·4	-2·28	+2·3	-2·49	+2·4	-2·63	+2·68	-(1·37+1·2)
POWER LEVEL. "			0·5		0·57		0·57		0·56		0·55		0·54		0·52		0·54		0·45		0·5	
VOLTAGE LEVEL. "			0·72		0·79		0·79		0·78		0·77		0·76		0·74		0·76		0·64		0·69	



LOSS OR GAIN. NEPERS	-1·0	-0·5	+2·2	-2·13	+2·2	-2·2	+2·4	-2·41	+2·3	-2·31	+2·4	-2·41	+2·4	+2·42	+2·4	-2·28	+2·4	-2·49	+2·5	-2·63	+2·7	-(1·37+1·2)
POWER LEVEL "			0·55		0·48		0·48		0·49		0·5		0·51		0·53		0·41		0·5		0·63	0·5
VOLTAGE LEVEL "			0·75		0·7		0·7		0·71		0·72		0·73		0·75		0·63		0·72		0·82	

CONVENTIONS.

DENOTES 4-WIRE REPEATER.

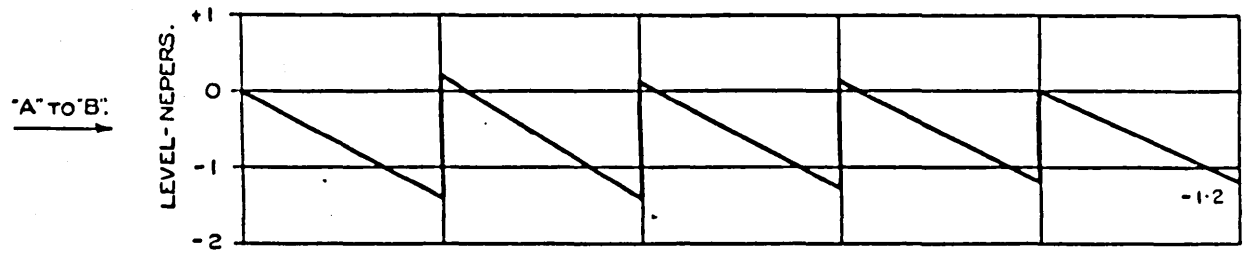
" CIRCUIT TERMINATION.

1·0 " ARTIFICIAL LINE. NEPERS = 1·0

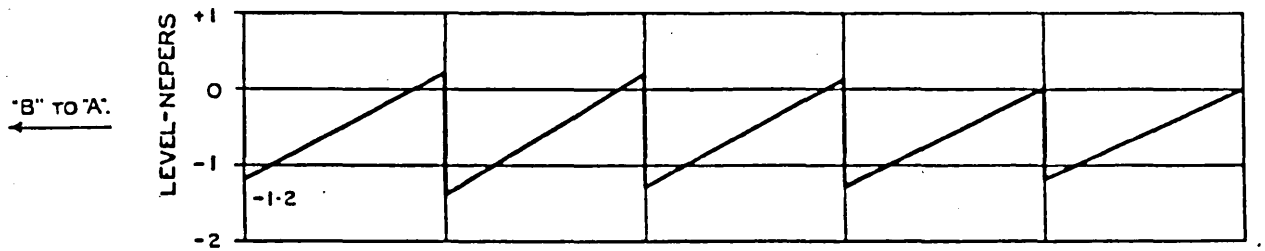
Level Diagram of the Circuit. Berlin—London 1 (Fk. 9950) German Section.



DISTANCE. KM.	149·4	147·4	143·8	69·8	104·5



LOSS OR GAIN. NEPERS	-1·4	+1·6	-(1·4+0·2)	+1·5	-(1·2+0·2)	+1·4	-(0·7+0·6)	+1·2	-1·2
POWER LEVEL "		0·2		0·1		0·1		0	
VOLTAGE LEVEL. "		0·7		0·6		0·3		0·2	



LOSS OR GAIN. NEPERS	-1·4	+1·6	-(1·4+0·2)	+1·5	-(1·2+0·2)	+1·4	-(0·7+0·6)	+1·2	-1·2
POWER LEVEL. "		0·2		0·2		0·1		0	
VOLTAGE LEVEL. "		0·7		0·7		0·3		0·2	

CONVENTIONS.

DENOTES 2-WIRE REPEATER.

" CIRCUIT TERMINATION.

0·2 " ARTIFICIAL LINE. NEPERS = 0·2.

Level Diagram of the Circuit. Hamburg—Amsterdam 2 (Fk. 1045).

APPENDIX V.

Programme of Routine Tests.

Circuits between.....and.....

No.	Circuit.		No. of Circuit.	Control Station.	Sub-Control Station.	Months, Days and Hours of Routine Tests.			Normal Values.						Remarks.
	from A	to B				Equivalent at 800 p : s.	Equivalent at 500, 800, 1400, 2000, and 2400 p : s.	Stability.	Equivalent at 800 p : s.	Equivalent at 500, 1400, 2000, and 2400 p : s.	Voltage Level at output of repeater at 800 p : s.			Stability.	
											Station.	Direction A to B.	Direction B to A.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
												néper / decibel	néper / decibel		

APPENDIX VI.

Form for statistics of non-utilisation of a circuit.

Non-utilisation of circuit.....during the period.....to.....

Service Interruptions.	Total.		Total interruption of Column 2 consists of :								
			Faults localised								
			In National territories			Total			In foreign territories		Intermittent faults (cannot be localised)
	For the whole length of circuit.	Per 100 km.	In Exchanges	In Repeater Stations.	In Line.	Total of Columns 4, 5 & 6	Per 100 Km.		Total for whole length of circuit.	Per 100 Km.	
							Open Wire.	Cable.			
1	2	3	4	5	6	7	8	9	10	11	12
Number											
Total duration in hours											
Average duration of a service interruption											

A. Total length of circuit .....Km.

1. In national territory .....Km.

Aerial lines .....Km.

Underground Cable .....Km.

2. In foreign territory .....Km.

B. Number of Repeaters .....Km.

1. In national territory .....Km.

2. In foreign territory .....Km.

MAINTENANCE OF CIRCUITS USED FOR THE RELAYING OF BROADCAST TRANSMISSIONS.*

Electrical Measurements for the Maintenance of Circuits used for the Relaying of Broadcast Transmissions.

The International Consultative Committee—

Unanimously advises :—

1 That for the maintenance of lines used for broadcast purposes measurements similar to those used for long-distance telephone traffic are necessary, *i.e.* :—

(*a*) Periodic measurements on the cable lines themselves for verifying the condition of insulation resistance, and the attenuation of the various repeater sections.

(*b*) Periodic measurements of the repeaters in order to determine whether the gain-frequency curve is satisfactory. For this purpose it is necessary to test with four frequencies within the transmission range effectively transmitted.

(*c*) Periodic measurements of the line used throughout its whole length in order to determine the total loss and the transmission level at the various repeater stations ; for this purpose it is usually sufficient, in accordance with long distance telephone practice, to make tests with a frequency of about 800 periods per second.

2. That volume measurements appear to be necessary only at the output end of the line ; the various Administrations are invited to use for these tests volume indicators (provisionally maximum peak indicators).

Division of Responsibility between Telephone Administrations and Radio-Broadcast Services (State or Private) regarding the Maintenance of Circuits used for the Relaying of Broadcast Transmissions.

The International Consultative Committee—

Unanimously advises :—

1. That the limit of responsibility of supervision between Telephone Administrations on the one hand, and the Broadcasting Authorities on the other, should be the protectors which are inserted at the broadcasting stations in the connections to the telephone exchanges at both ends of the line.

2. That when there is a broadcasting circuit in a long-distance telephone cable, the rôle of the control station should be the same as it is in ordinary telephone communication.

3. That it is desirable to designate, for each circuit used in broadcast relay and in each country, a particular repeater station to supervise, permanently, the broadcast transmission and, in urgent cases, take measures to remedy any fault it may observe.

Technical Responsibility in connection with the Renting of International Telephone Circuits to Broadcasting Authorities.

The International Consultative Committee—

Unanimously advises :—

That the Broadcasting Authorities should be responsible for the supply of broadcasting energy at the requisite level, while the control station of the Telephone Administration should control the transmission over the telephone circuits as in the case of ordinary telephone connections.

* This replaces the text under the same title on pp. 370–373 of *Livre Jaune* (English version, pp. 221–222).

Instructions to Broadcasting Organisations and to Terminal Exchanges or Repeater Stations of Telephone Administrations for putting into operation a connection to be used for Broadcast Transmission, and for the re-establishment of this connection to its normal service.

1. The instructions given by the C.C.I. regarding the establishment and maintenance of telephone lines used for long-distance traffic are also suitable for lines used for the relay of broadcast transmission. They involve the establishment and exchange of circuit charts, and of level diagrams for all lines in regular service, the measurement of equivalents and levels at regular intervals of time, and at frequencies which have been fixed for every line by the different technical departments concerned. In addition, the gain of the repeaters used for broadcasting must be measured at one or more frequencies, and it is necessary to designate control and sub-control stations, etc.

2. The lines used for the relay of broadcast transmissions should be ready half an hour before the beginning of a radio transmission. The terminal exchange and the repeater stations must previously regulate the gain of the repeater to be connected to the value given on the circuit chart, and, by means of a test at a frequency of 800 p : s, it must be verified that the gain really has this value. The results are communicated to the control station and to the sub-control station on demand. The two terminal exchanges will then test the equivalent at a frequency of 800 p : s; different repeater stations simultaneously test the level. If it is necessary to modify the levels, the control station shall decide what is to be done in conjunction with the sub-control station. The control station is always to be the terminal exchange in the direction of the transmission, because it is only this station which can correctly assess the transmission. As soon as the attenuation test shows that the line is in good condition, the line is transferred to the Broadcasting Organisations at its two extremities.

3. In addition to the transmission line, Broadcasting Organisations may employ a line for conversation. It is desirable, where possible, that this line should serve several telephone instruments in the different control posts of the Broadcasting Organisations concerned.

4. After the Broadcasting Organisations have taken possession of the lines connected, they will make tests on the whole connection serving the broadcasting transmission, from the studio to the transmitting station, over the whole band of frequencies to be effectively transmitted, by means of self-recording apparatus (level recorders), which enable more rapid tests to be made. These devices must be designed so that they permit of simultaneous testing (at a frequency of 800 p : s) of the levels at the intermediate stations.

5. Broadcasting Organisations should never exceed the limit selected by Telephone Administrations concerned for the maximum power supplied to the transmission line. As regards supervision of the broadcast transmission, it is recommended that the Broadcasting Organisations (at the studio, at the outgoing side of the repeater, and at the transmitting station, after the final low frequency amplifier) as well as the two terminal stations, install volume indicators; provisionally peak indicators with duration of integration not greater than 20 milliseconds. Regarding intermediate repeaters, it is recommended that volume indicators of this type should also be held in readiness, in order that it may be possible rapidly to localise any faults which may arise. In this case, the studio supplies to the line a fixed and constant power (transmission of a dash—" émission d'un trait ").

6. As soon as the Broadcasting Organisation announces to the control or the sub-control station that the broadcast transmission is finished, the latter will switch off the repeaters, and, when long-distance

telephone lines to be employed with other repeaters are concerned, the control station replaces the repeaters used for broadcasting by repeaters normally used for telephony.

In cases where the connection between a circuit used for relaying radio-broadcast transmissions and the radio apparatus is carried out by the technical department and not the operating department, the technical departments should make arrangements to find out, after the preliminary tests, the moment the circuit is placed at the disposal of the Broadcasting Company (this is the beginning of the taxable period) and also determine at the end of the transmission the moment when the circuit is set free by the Broadcasting Company (this is the end of the taxable period).

The terminals of the last lines put into operation form points dividing the responsibility between the Broadcasting Organisation and the Administrations whose duty it is to put these lines in working order. As regards testing the circuits, the Telephone Administrations use, for the preliminary test, the apparatus connecting the lines to the studio. These tests are not extended to the operating rooms of the Broadcasting Organisations unless the tests between the terminal exchanges of the line show that the fault is situated between the terminal exchange and the repeater rooms of the Broadcast Organisations.

7. It is desirable to identify by means of a special mark in exchanges and repeater stations the circuits and apparatus to be used for the relay of broadcast transmission, and to instruct the personnel never to come in on the circuits unless necessary for service reasons.

Note.—The above recommendations should be considered as provisional. Before they can be modified it will be necessary to observe on several circuits, used for broadcast relay purposes, the number and nature of the operations required on such circuits during each broadcast transmission before they are ready to be turned over to the Radio-diffusion organisation as well as the measures to be taken and methods to be used in order to reduce the time taken for their preparation to a minimum. The Administrations of Germany, Austria, Belgium, Great Britain and Czechoslovakia have agreed to undertake this study for the case (1) where only one circuit is used in a relay and for the case (2) where several circuits are used. The results of their study will be submitted to the General Secretariat of the C.C.I., which will communicate this information to the Administrations and Operating Companies, belonging to the C.C.I.

(A.f.)

CO-EXISTENCE OF TELEPHONE AND TELEGRAPH CIRCUITS IN THE SAME CABLE.*

The International Consultative Committee—

Considering:—

That technical arrangements already exist which permit telephone and telegraph service in the same cable, either over separate conductors or even over common conductors; that with these arrangements, and by taking the precautions stated below, the telephone circuits, including phantoms, are practically not influenced by the telegraphs, either from an electrical or from a traffic standpoint;

That even when the cable is subject to influence by power systems (in particular, railroads using A.C.), it is possible to obtain a telephone and telegraph service free from interference troubles by using devices which have already proved satisfactory in practice;

That, furthermore, the simultaneous use of long-distance cables for telephony and telegraphy is recommended for economical reasons;

Unanimously advises:—

That the simultaneous exploitation of international telephone and telegraph circuits in the same cables be forthwith accepted in principle, either over separate conductors or common conductors, on condition that all measures be taken to ensure that the telegraph does not interfere with present and future telephone traffic;

* This test replaces that under the same heading in *Livre Jaune*, pp. 373-376 (English Version, pp. 223-225).

That the provisional conditions which, in the present state of the technique, shall be met by simultaneous or co-existent telegraph and telephone installations, are as follows :—

Ia Simultaneous Telegraphy and Telephony over the same Conductors (or Infra-Acoustic Telegraphy).

In order not to prejudice the transmission quality of telephone circuits the following requirements must be met :—

1. The e.m.f. produced in the line circuit by the telegraph transmitter must not exceed 50 volts.

2. When the terminals of the telegraph transmitter are closed through a resistance of 30 ohms substituted for the line, the current through this resistance must not exceed 50 mA. This limit is increased to 100 mA if the cable is equipped with coils having cores of compressed iron dust.

3. The increase in the attenuation of the telephone line due to infra-acoustic telegraph installations must not exceed 0.06 néper or 0.52 decibel for a repeater section, and over the frequency range between 300 p : s and the maximum frequency transmitted.

4. Over four-wire circuits the variation of line impedance produced by infra-acoustic telegraph installations must not exceed 10 per cent. in the frequency range indicated. As regards two-wire circuits, infra-acoustic telegraph installations must not exceed the values prescribed by the Telephone C.C.I. for the exact simulation of the impedance of the line by balancing networks. (*See* Appendix B.d. 2, No. 3—Impedance Unbalance.)

5. The noise voltage, due to telegraphs, measured objectively at the end of the telephone circuit must not exceed a value which corresponds to a noise voltage of 1.0 mV for a transmission level of —1 néper or —8.7 decibels for an impedance of 600 ohms.*

6. The increase in crosstalk produced by infra-acoustic telegraph installations shall be determined as follows :—

The cable quads are replaced by artificial lines free from crosstalk and reproducing within the closest possible limits the impedances of the circuits (terminal apparatus for quads). Under these conditions the attenuation corresponding to the crosstalk measured from the telephone office side must not be inferior to the following values :—

(*a*) For four-wire circuits : 7·5 népers or 65 decibels for the crosstalk between any two speech circuits in the same quad ;

(*b*) For two-wire circuits : 8·5 népers or 74 decibels for the crosstalk between any two speech circuits in the same quad ;

(*c*) For four-wire and two-wire circuits : 10 népers or 87 decibels for the crosstalk between two speech circuits in different quads.

7. After infra-acoustic telegraph systems are connected into a circuit, the unbalance to earth of the telephone circuits must not exceed the value prescribed by the C.C.I. (" Guiding Principles," 1930 Edition, pp. 3-4.)

8. The circuits employed for infra-acoustic telegraphy must not be used for relaying broadcast transmission, as the low frequencies are used for a good reproduction of music.

Ib Simultaneous Telegraphy on Phantom or Super-Phantom Circuits (using, for instance, two quads in Dieselhorst-Martin cables or two pairs in star quad cables). The conditions which are given in Part I., in paragraphs 1, 2, 5, 7 and 8, must be fulfilled. Further, the increase in the crosstalk

* The definition of noise voltage, the measurement of its magnitude and the limit to be placed on interference noise from all sources, form part of the study, and are the subject of investigation by the International Mixed Commission dealing with the protection of underground cables and lines for tele-communication.

produced by the simultaneous telegraph-installations in telephone circuits must not exceed a value corresponding to a decrease in the crosstalk attenuation of 0.5 néper.

II. Simultaneous Telegraphy and Telephony over Separate Conductors.

1. Where the telegraph uses loaded conductors which may later be used for telephony, the conditions stated under heading I., Nos. 1, 2 and 5, must be fulfilled.

2. Where the telegraph uses non-loaded conductors, paragraph 5 of heading Ia. need only be fulfilled.

III. Harmonic Telegraphy.

The total power of telegraph currents corresponding to the frequencies utilised simultaneously on one and the same telephone circuit should not exceed 5 mW at zero level, deduced from the diagram of the power levels of the telephone circuit.

As, in the majority of cases, the harmonic telegraph transmitter is not connected at the input of the telephonic circuit, there exists, in general, at the input of the harmonic telegraph circuit an absolute level (p) deviating from zero level. The maximum power permissible at the input of the harmonic telegraphic circuit therefore amounts to :—

$$N_{max} = 5\, e^{2p} \text{ mW}$$

and the maximum tension for an impedance Z of the circuit to :—

$$E_{max} = (5 \cdot 10^{-3} \cdot e^{2p} \cdot Z)\ \tfrac{1}{2} \text{ volt}$$

In multiple harmonic telegraphy with n frequencies, this tension will certainly not be exceeded, provided that the tension E_f does not, for any frequency, exceed the nth part of the maximum admissible tension :—

$$E_f = \frac{1}{n} \cdot E_{max}$$

or that instead of the power level p, the tension level p_s is introduced, whose relation to the former is given by :—

$$p_s = p + \log_e \sqrt{\frac{Z}{600}}$$

$$E_f = \frac{1}{n} \cdot e^{p_s} \cdot \sqrt{3}$$

The tests are effected in applying each frequency one after the other to the circuit. For this purpose each generator is regulated so that for each frequency the value of the tension specified above is obtained. The voltage test to be carried at the input of the multiple harmonic telegraph circuit may be carried out with any type of suitable voltmeter.

If normal level measuring apparatus is used (hypsometers) which are graduated in absolute levels, the value of the absolute level must not exceed for a system with n channels:—

$$p_{mes} = p_s + 0.8 - \log_e n$$

Should the absolute voltage level at the points relative to zero level of the harmonic telegraph circuit amount to $p_s = 0.7$, for instance, the regulation should be based on the following test values :—

3	Channel System	:	$p_{mes} = 0{\cdot}7 + 0{\cdot}8 - \log_e 3 = +0{\cdot}4$ néper
6	,,	:	$p_{mes} = 0{\cdot}7 + 0{\cdot}8 - \log_e 6 = -0{\cdot}3$,,
12	,,	:	$p_{mes} = 0{\cdot}7 + 0{\cdot}8 - \log_e 12 = -1{\cdot}0$,,

It is estimated that it is not necessary to control tensions or powers during the exploitation of the system.

(A.g.)

CO-ORDINATION OF RADIO TELEPHONY AND TELEPHONE SYSTEMS.

General Conditions to impose upon radio telephone circuits.

The International Consultative Committee—

Considering :—

That the use of a radio link in a long-distance telephone circuit involves certain special conditions with consequent particular difficulties which are not encountered when using wire circuits exclusively.

That a radio telephone circuit differs from a metallic circuit in the following respects :—

1. A radio telephone circuit is subject to variations of attenuation, with the particular difficulty of "fading," which is characteristic of transmission with very high radio frequencies.

2. A radio telephone circuit suffers from the noise of "atmospherics," varying in intensity from a negligible quantity to a strength of the same order as the signal it is desired to receive.

3. Special precautions are necessary in the design and maintenance of a radio telephone circuit in order to avoid, at the radio receiving station, interference from the radio transmitter used for other services; in other words, abnormal "singing" and "crosstalk" conditions must be avoided or corrected.

4. In order to maintain the radio link at the best standard of transmission, it is necessary to provide special means for ensuring that the radio transmitter is fully loaded, as far as possible, whatever the nature and attenuation of the extension connected to the radio telephone circuit.

5. The band of voice frequencies which can be transmitted by the radio link may be limited by one or more of the following conditions :—

(*a*) The necessity for economy in the frequency spectrum used for radio transmission.
(*b*) The use of a low radio frequency.
(*c*) The necessity for electrical filters in connection with the particular system of transmission used.

6. A radio telephone circuit is usually a long-distance inter-continental circuit providing a telephone service between two extensive networks, and this fact is of great importance from two points of view :—

(*a*) It is desirable that the standards of transmission aimed at for such a radio telephone circuit should be higher than those at present laid down for long-distance metallic circuits.
(*b*) In the present state of the art, a valuable service should not be denied to members of the public under the pretext that it does not at all times reach the standard of excellence desirable for long-distance communications.

Unanimously advises :—

1. That the band of frequencies transmitted by a radio telephone circuit should not be less than that recommended by the C.C.I. for long-distance international telephone circuits, *i.e.*, 300 to 2500 p : s (*see* Appendix B.d. 2, No. 4), but it is desirable, if possible, to provide a wider frequency band than this, and, where practicable, the radio telephone circuit should be designed for a frequency band of not less than 200 to 3000 p : s.

Note.—In the present state of the art, it might be desirable to use provisional frequency bands differing from those specified above, if improved transmission results therefrom, *e.g.*, on account of a reduction in the volume of interference.

2. That the normal attenuation of a radio telephone circuit should not be greater than the limit recommended for long-distance circuits, viz., 1.3 nepers or 11.3 decibels, but where practicable, a radio

telephone circuit should be designed to have less than this attenuation under favourable radio conditions; that, as in the present state of development, it is not practicable rigidly to maintain a radio telephone circuit below the limit of 1.3 népers or 11.3 decibels, a certain amount of latitude should be permitted under unfavourable radio conditions, rather than that a valuable long-distance service should be denied to subscribers. It must be recognised that, under unfavourable radio conditions, it might be necessary to do without the extensions normally possible by a radio link through the medium of wire connections.

3. That every endeavour should be made to minimise the noise level relative to speech, by the use of such radio devices as directive antennæ, etc. That it is, however, necessary to tolerate wide variations in the noise level on a radio telephone circuit. Further, that in the present state of the art, neither a limiting ratio of noise to speech, nor a method of measuring noise, can, as yet, be recommended.

That, provisionally, the following values can be taken as a general guide for the noise level on a radio telephone circuit:—

(*a*) Under average radio conditions, a mean noise voltage of 25 mV in 600 ohms at zero level, corresponding to a mean rectified power of 0·001 milliwatt, may be expected.

(*b*) Under unfavourable radio conditions, a mean noise voltage as high as 200 mV in 600 ohms at zero level may be tolerated, if the extension circuits, including the subscribers' circuits, are of sufficiently high grade (this noise voltage corresponds to a mean rectified power of 0·067 milliwatt). It must be ascertained that the noise voltage is not sufficient to affect the echo suppressors with which the extension circuits may be equipped. In connection with the last point, it may be assumed that a potential of 80 millivolts at zero level will operate the echo suppressors used, if applied during a time interval greater than the duration of the first transient period of this apparatus.

It should be noted that such an occurrence will cause no serious inconvenience, unless frequently repeated.

4. That the extension circuits connected to a radio telephone circuit should conform to the various recommendations of the C.C.I. for normal metallic circuits in regard to the transmission equivalent, distortion, noise, echoes, transient phenomena, etc., in particular, the following:—

(*a*) The reference equivalent of the transmitting system from a subscriber and the terminals of the radio telephone circuit should not exceed 2·6 népers or 23 decibels. The reference equivalent of the receiving system, comprising a subscriber's set and the chain of circuits and equipment leading up to the terminals of the radio telephone circuit should not exceed 2·0 népers or 17 decibels.

(*b*) The noise voltage should not exceed the provisional value of 5 mV in 600 ohms at the transmission level of —1 néper.

(*c*) The echo effects should not be greater than the limits indicated by the curves and recommendations of the C.C.I.

(*d*) The duration of transient phenomena in extension circuits should be such that, for any frequency within the band transmitted and for the complete circuit between subscribers (including the radio telephone circuit and both extension circuits), the total duration of a transient phenomenon shall not exceed 30 milliseconds.

5. That, in cases where a radio telephone circuit utilises a fairly low frequency band, making it necessary, on account of the congestion of radio services in the frequency spectrum, to use the same frequency band for transmission in both directions, a voice-operated switching device should be incorporated in the radio telephone circuit in order to avoid " singing," or interference from a radio transmitter on the receiving station.

Although it is not always essential, from the technical point of view, to use a voice-operated switching device where the same frequency band is not used for radio transmission in both directions (as is the present practice with very high radio frequencies), it is desirable that such devices should be fitted in order that the radio telephone circuit can be used,

(*a*) with a low equivalent, and

(*b*) for the inter-connection of two long-distance extension circuits which, in the absence of such devices, would constitute a circuit with excessive echo effects.

6. That, in the present state of the art, and in order to maintain the necessary speech levels, a radio telephone circuit should be under the continuous observation of a technical operator at a position equipped with suitable instruments for indicating speech volumes and the mean noise voltage, and that this operator should be able to adjust the speech volume so as to load the radio transmitter fully, and also to make any

necessary adjustment of the circuit conditions (including any voice-operated devices) to meet the varying conditions of speech volume and noise in respect of the transmission on the radio telephone circuit.

7. That, when utilising very high radio frequencies, an automatic gain control should be fitted to the radio telephone circuit to compensate automatically, and as far as practicable, for the radio phenomenon of "fading."

8. That the radio circuit should be terminated in such a manner that it can be connected to any other type of circuit in the normal way.

An Instrument which allows the Special Operator, located at the junction of a Radio Link and a Metallic Circuit, to measure Voice Power.

The International Consultative Committee—

Unanimously advises :—

1. That the instruments which it is necessary to install at the technical operator's position depend upon the information required on the instantaneous power being transmitted by the circuit.

2. That present practice is ordinarily to use two different instruments which, moreover, can be of different types. The first indicates the peaks and the second follows the changes in average power. Thus, on the one hand, the transmitter is protected against too frequent overloading (sometimes an automatic limiter is used) and, on the other, the transmitter modulation is kept at its optimum value. It is desirable in certain cases to use both types of instruments at the same time.

3. That it is possible, however, to use one instrument which integrates the power being transmitted by the circuit over a period equal to the maximum period during which overloading is not inconvenient. The constants of such an instrument can also be made such, that it can either work as a peak indicator or a power indicator as required. It is then possible to control the modulations so that the instrument needle only occasionally exceeds a fixed limit.

4. That, although the working of long-distance radio links does not compel the standardising of characteristics of different instruments, it is nevertheless very desirable finally to adopt uniform characteristics for apparatus used by different Administrations and Operating Companies, so as to render possible comparison of results obtained at the two ends of the same link. The advice of the C.C.I. on "Characteristics Recommended for Speech Power Indicators and Peak Indicators" should be followed. (*See* p. 37.)

Protection of Echo or Reaction Suppressors used on Radio Telephone Circuits.

The International Consultative Committee—

Considering :—

That, as far as concerns the protection of reaction suppressors (echo suppressors) located at the technical operator's position against false operation by static noise, a measuring instrument is not always necessary, and that it is sufficient to use a simple indicator, functioning each time the reaction suppressor is operated (the technical operator regulating the gain in consequence).

Considering further :—

That a measuring instrument will sometimes be found desirable in the case of reaction suppressors, and that it is always essential on land lines equipped with echo-suppressors;

Unanimously advises :—

That, to protect reaction suppressors (or echo suppressors) located on a radio link against false operation by static noise, it recommends the use of either a speech power indicator or a peak indicator, conforming to the advice of the C.C.I. thereon (*see* p. 37), taking care that the frequency response characteristic corresponds to that of the suppressor which it is designed to protect.

Conditions to impose upon Mobile Telephone Stations communicating with the Public Land Network.

The International Consultative Committee—

Considering :—

That the experience acquired up to the present does not enable a reply to be made to this question for mobile stations other than those of passenger carrying ships;

That it is possible to organise a commercial service of long-distance radio telephony, connecting passenger carrying ships to the public telephone network;

That the information at present available permits the indication with a certain precision, from the point of view of telephone technique, of the technical and operating conditions to effect for the carrying out of this service.

Unanimously advises :—

That in so far as it concerns the telephone technique it will sometimes be sufficient, in a ship installation, to use a telephone and a microphone which are separated; on the other hand, on land, it is recommended to apply all the measures which are employed in the long-distance radio-telephone service between fixed points, and which have for object the prevention of echo effects and the passing of sound from the receiver into the land transmitter. When the service is effected within a small zone, it will eventually be possible to do without a voice operated device.

Note.—The C.C.I.R. have examined this same question from the point of view of radio electric technique and have given their recommendations on this subject.

B. ESSENTIAL CLAUSES OF TYPICAL SPECIFICATION.*

The International Consultative Committee considers that the efficiency of a long-distance cable (containing several repeaters) depends to a large extent on questions of details of construction and of the general arrangement of the system.

The International Consultative Committee proposes to recommend to an Administration which would prefer to leave the proposal for a complete cable, including several repeaters, in the hands of the contractor, instead of having a service of specialised engineers and of assuming the responsibility which would result from the acceptance of the various portions of the system separately, to discuss matters in detail with the contractor, in order to obtain necessary information with regard to the lay-out, general arrangements, etc., and to demand all the guarantees desired in order that the conditions specified in the partial specifications, appended, shall be duly fulfilled. At the outset, this Administration should give the contractor information in respect to the circuits which will be necessary, and with respect to the probable traffic.

* This text replaces that under the same heading on pages 386-448 *Livre Jaune* (English version, 230-270).

Certain Administrations show, in their proposals respecting specifications for underground cables, details with respect to methods of construction, laying, etc. These are not included in the typical specifications dealt with in Appendices B, because the C.C.I. is of opinion that it is preferable to give a free hand to the various Administrations in respect to the choice of their methods relating to everything that concerns construction and laying of the cables, subject to the condition that the circuits established will satisfy the conditions imposed by the appropriate specifications.

It is specified in Appendix B.d.2, No. 1, that when the processes of manufacture do not admit of realising, with sufficient approximation, equality of the capacities of the various loading sections included between two successive telephone repeaters, this equality should be obtained as perfectly as possible by suitably distributing factory lengths amongst these loading sections.

Precise rules have been specified in Appendix B.d.2, No. 5, in respect to the spacing of loading coils in cables. If, in consequence of local circumstances, a regular spacing of these loading coils cannot be observed, the special arrangements adopted in this case should be such that the result will not be detrimental.

Some Administrations prefer, in carrying out tests of dielectric strength of the cables in the factory, to apply the testing voltage for two (2) minutes instead of two (2) seconds specified in Appendix B.d.2, No. 1. The C.C.I. does not see any objection to this method of procedure.

The rules and specifications will be found in the following Appendices: B.b.2, Nos. 1 and 2; B.b.3, No. 1; B.c.3, Nos. 1, 2 and 3; B.c.4, Nos. 1 to 9; B.d.2, Nos. 1, 2, 3, 4 and 5.

APPENDIX B.b.2, No. 1.

INSTRUCTIONS FOR DRAWING UP A TYPICAL SPECIFICATION FOR THE SUPPLY OF A MULTIPLE TELEPHONE INSTALLATION USING HIGH FREQUENCY CARRIER CURRENTS FOR INTERNATIONAL SERVICE.*

1. Multiple telephony by high frequency carrier currents can be used either on open-wire lines or on special cables.

2. The distribution of frequencies can be, for example, the following:—

Up to 300 p : s—infra-acoustic telegraphy.
From 300 to 3 000 p : s—low frequency telephony.
Above 3 000 p : s—high frequency telegraphy and telephony.

If low frequency telephony is used for the relay of radio-broadcast transmissions, a frequency band larger than the above frequency band, *e.g.*, from 50 to 10 000 p : s, should be reserved for this use.

3. A high frequency telephone communication can be realised, either by using the same frequency band on the outgoing transmission and on the incoming transmission, or by using different frequency bands for the incoming and outgoing transmissions.

4. It is to be recommended that only one side band of the modulated carrier current should be transmitted along high frequency channels. In the case of speech transmission, this side band should correspond to a low frequency interval of, at least, from 300 to 2000 p : s. In this case, the carrier current can either be suppressed or transmitted at the same time as the side band.

In the case of a suppressed carrier current system, the oscillators used at ends of the same channel should either be supplied with a synchronisation device, or should show a sufficient frequency stability not to require too frequent adjustments (*e.g.*, more than once a week).

* The figures quoted in this Appendix correspond to the present position of telephone engineering practice, and should be considered as provisional.

5. A system providing a complete high-frequency telephone communication comprises :—

(*a*) Two terminating sets for connection with a toll line, or with a subscriber's line.
(*b*) Two transmitters.
(*c*) Two receivers.
(*d*) Filters for separating the various frequency bands, and duplex apparatus in the case where the same frequency band is used for both directions.
(*e*) Devices for signalling, monitoring and control.
(*f*) Intermediate repeaters, if necessary.

Half of the system is installed at each terminal high frequency station, *i.e.*, a terminating set, a transmitter, and a receiver, as well as the associated filters and monitoring devices.

Filters, devices for monitoring and control, and duplex apparatus, if it is desired to use the same range of frequencies in both directions, are installed at each repeater station.

6. The levels of the complete connection—toll exchange, high frequency station, open-wire line, high frequency station, toll exchange—should be so fixed that :—

(*a*) The equivalent measured at 800 p : s between two toll offices does not exceed 1·3 népers or 11·3 decibels.
(*b*) In certain cases (through traffic, mixed circuits comprising long cable sections) it is desirable to be able to attain a resultant gain of 1·3 népers or 11·3 decibels between high frequency stations.
(*c*) The high frequency level* at the origin of the open-wire line shall not exceed +2 népers or 17·4 decibels.
(*d*) The high frequency level at the end of an open-wire line shall not be less than —4 népers or 35 decibels.

Where the line connecting the toll exchange to the high frequency station has an attenuation of 1.3 népers, or 11.3 decibels, the diagram showing the levels is, for example, the following :—

—	Toll Exchange.	High Frequency Station.	Open-Wire Line.	High Frequency Station.	Toll Exchange.
Low frequency level measured at 800 p : s	0	—1·3 népers or —11·3 decibels	—	0	—1·3 népers or —11·3 decibels
High frequency level	—	—	+2—4 népers or +17·4—35 decibels.	—	

7. The range of a high frequency communication should be in agreement with the range of the low frequency communications on the same open-wire line.

With normal equivalents, the ranges obtained for low frequency communications are as follows :—

Open-wire lines of copper or copper alloy, the conductivity of which does not vary by more than 10 per cent. from that of high conductivity copper—

Diameter	2 mm	3 mm	4 mm
Range	150 km	300 km	500 km

On any carrier communication channel, the attenuation of the line is then not more than 5 népers or 43 decibels. Intermediate repeaters are necessary to obtain greater ranges.

The attenuation characteristic of a repeater section should be as regular as possible. In the case of a duplex system, the impedance for any frequency should not differ from the mean impedance curve by more than 20 per cent.

* A low-frequency generator placed at the end of the line (toll station) produces, at the near end of the open-wire line, the side band frequency of $b-n$ or $b+n$. The "absolute low-frequency level" is the absolute current level of frequency n, and the "absolute high-frequency level" is the absolute current level of frequency $b-n$ or $b+n$ transmitted.

8. In regard to near and far end crosstalk, and to the absence of disturbing noises, the different high frequency channels should satisfy the conditions which hold good for the use of low frequency.

Crosstalk attenuation (near or far end) measured at low frequency at the toll station between two high frequency channels, or between a high frequency channel and the low frequency channel on the same circuit, should exceed 7.5 népers or 65 decibels; the crosstalk attenuation measured under the same conditions between any two high frequency channels using wires on the same pole line should exceed a value fixed provisionally at 6.2 népers or 54 decibels.

The attention of Administrations and Operating Companies is directed to the extreme desirability of obtaining a crosstalk value corresponding to a higher degree of attenuation and to ensuring that all practicable measures should be taken to this end.

In order to reduce as much as possible the crosstalk between the different carrier current connections on circuits on the same pole, it is recommended to adapt, in terminal stations and repeater stations, the input impedances of the apparatus to the characteristic impedances of the circuits to which they are connected, for the most important frequencies of the band transmitted, as far as this is possible from both economic and technical points of view. Provisionally the adaptation should be so arranged that $2\left|\frac{\mathfrak{z}-w}{\mathfrak{z}+w}\right|$ does not exceed the value of 0.8 both for the input impedance and the output impedance ($\mathfrak{z}$ being the line impedance and w the terminal apparatus impedance).*

The noise voltage measured at the terminals of the circuit in the toll exchange should be less than 5 mV.†

9. The supervisory device must include :—

(*a*) Testing instruments for voltages of the filament, plate and grid batteries.

(*b*) Apparatus for the measurement of the carrier current at the near end.

(*c*) Apparatus for the measurement of the carrier current at the far end.

(*d*) Installations for the control of low and high frequency repeaters.

(*e*) A device for signalling, listening and speaking.

(*f*) An alarm device arranged to function when the reception level deviates above or below the normal level by a certain amount (for example, ±0·2 néper or ±1·7 decibels).

Items (*b*) and (*c*) also serve for verifying the line attenuation.

In suppressed carrier current systems, an auxiliary frequency is transmitted to permit of controlling the line attenuation; in this case, the measuring apparatus (*b*) and (*c*) should be suitable for this auxiliary frequency.

10. Receiving apparatus should comprise a regulating device, enabling the low frequency transmission equivalent on each channel to be adjusted in accordance with the indications given by the control apparatus.

11. The supplementary attenuation produced in ordinary low frequency conversation by the whole equipment of the line, in view of the use of high frequency, should not exceed 0.15 néper or 1.3 decibels for any frequency between 300 and 2 000 p : s when there are no high frequency repeaters on the line.

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* *See* Addendum to Appendix B.b.2, No. 1 on this subject.

† This figure is provisional; its definite determination will depend on the joint deliberations of the 3rd Commission of Assessors and of the 6th Sub-Committee of the C.M.I. (International Mixed Commission).

12. When the circuit equipped for carrier current telephony is combined with another circuit. the presence of high frequency installations must not disturb the operation of the combined circuit, For this reason, the same line filters should be reproduced on the other side circuit.

13. The installation should take into consideration the transmission of the ringing current (16 to 25 p : s or 20-500 p : s). It should enable signals to be transmitted direct from toll station to toll station with intermediate ringing of the two high frequency stations.

14. It is necessary to inter-connect high frequency circuits in such a manner that—

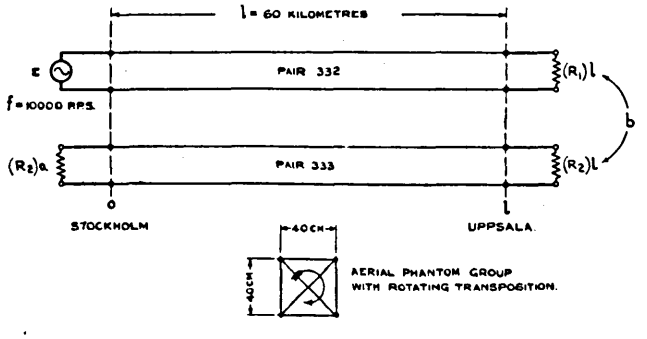
(*a*) No additional echo is produced.

(*b*) The levels in each circuit do not vary by more than plus or minus 0·2 néper or plus or minus 1·7 decibels.

ADDENDUM TO APPENDIX B.b.2, No. 1.

It would be interesting if those Administrations who have had the opportunity to make experiments on this subject, would state whether the provisional value (0.8)* which figures in the preceding text is sufficient in the case of lines containing a small number of carrier current circuits as well as in the case of lines containing a large number of these circuits. As an example, the result of tests made, in collaboration, by the Swedish Telephone Administration and the Empresa de Telefonos Ericsson, are given below.

In a study entitled "On Crosstalk between Telephone Circuits" published in the "L. M. Ericsson Review" of June, 1930, Dr. Vos has shown that for carrier current telephony using different frequencies for the two directions of transmissions, it is possible greatly to reduce the far end crosstalk—which is the only important crosstalk in this case—between the different high frequency channels on the conductors of the same pole route, by designing the apparatus of the end stations and of the repeater stations so that the input impedance of this apparatus matches, as much as possible, the impedance of the circuits to which they are connected for all important frequencies.



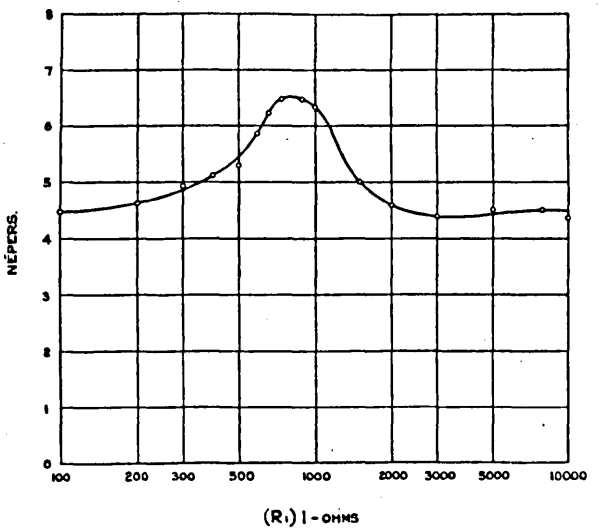
In order to verify the theory, measurements have been made on the open wire line between Stockholm and Upsala, a distance of about 60 km. The far end crosstalk was measured between the two pairs 332 and 333 of a phantom group consisting of 3 mm diameter copper wires. The conductors are arranged in accordance with the method shown in the schematic (above). The group is transposed in accordance with the usual methods applied in Sweden.

Test No. 1 (curve K_1—160).—The disturbing pair (332) was supplied at the sending end (Stockholm) by a 10 000 p : s alternating current generator (E). At the receiving end (Upsala), the same pair was terminated by a non-inductive resistance $(R_1)l$ which was varied gradually during the test. The disturbed

* *See* p. 136.

pair (333) was terminated at the sending and receiving ends by a constant non-inductive resistance corresponding to the characteristic impedance of the circuit. The curve K_1-160 shows the relation between

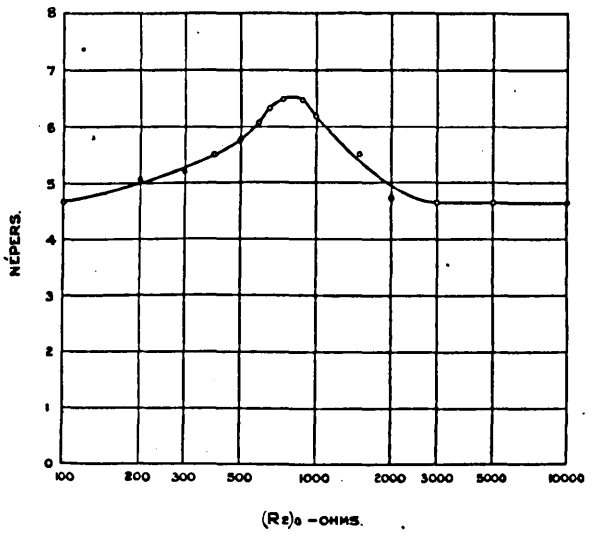
K_1—160.



the far-end crosstalk attenuation and the value of the terminal resistance $(R_1)\ l$ of the disturbing circuit. It will be noticed that the crosstalk attenuation increases considerably when the terminal resistance $(R_1)l$ approaches the characteristic impedance of the line.

Test No. 2.—The measurements were made in a similar manner, the only difference being that the resistance $(R_1)l$ was kept constant and equal to the characteristic impedance of the line, while the terminal

K_1—159.



resistance $(R_2)_0$ of the disturbed circuit at the sending end was gradually varied during the test. The curve K_1-159 shows that for this measurement a similar relation exists between the crosstalk attenuation and the value of the terminal resistance $(R_2)_0$.

Conclusion.—The tests described show the great importance of a good matching with the line of the sending, receiving and repeater apparatus in carrier current telephone systems.

APPENDIX B.b.2, No. 2.

GUIDING PRINCIPLES FOR DRAWING UP A SPECIFICATION FOR THE SUPPLY OF A HIGH FREQUENCY REPEATER STATION.*

1. The range of high frequency communication can be increased by means of intermediate repeaters. It is desirable to install high frequency repeaters at the same spacing as low frequency repeaters, *i.e.*, at intervals of 250 to 500 km.

2. The maximum gain of an intermediate repeater must amount to, at least, 3 népers or 26 decibels.

3. The incoming level must not fall below −4 népers or 35 decibels. The outgoing level must not exceed +2 népers or +17.4 decibels.

4. It should be possible to regulate the gain, either in accordance with the prescribed value for amplified carrier current, or in accordance with the amplitude of the auxiliary frequency transmitted. (in the case where the carrier current is suppressed).

Where the same repeaters serve simultaneously for all the channels, they should be supplied, for each direction, with an equaliser or correcting device to ensure the same transmission equivalent on all these channels.

5. The repeater should comprise, in addition to the measuring instruments supplied for the purpose of verifying the operating voltages, a device to show the value of the amplified carrier current (or of the auxiliary frequency current). It is further desirable that a listening device should be provided.

6. The effects of parasitic modulation, between currents of one band, or between currents of two different bands amplified simultaneously, being of such a nature as to cause noise or crosstalk between the channels of the same system, the high frequency repeaters should be so constructed that these parasitic modulation phenomena are systematically eliminated.

7. Supplementary attenuation produced in ordinary low frequency conversation by the insertion of a complete high frequency repeater, should not exceed 0.15 néper or 1.3 decibels for any frequency between 300 and 2000 p : s.

8. If, at the points where the high frequency repeaters should be installed, there are already low frequency repeaters, the balancing networks of these low frequency repeaters should be modified during the installation of this new equipment.

APPENDIX B.b.2, No.3.

GUIDING PRINCIPLES FOR THE FORMATION OF ESSENTIAL CLAUSES FOR A SPECIFICATION FOR THE SUPPLY OF TWO-BAND TELEPHONE SYSTEMS ON INTERNATIONAL CIRCUITS.

1. Definition.

Two-band telephony is a system which makes use of a single pair of wires of a cable to communicate by low frequency in one direction and by high frequency in the other direction, Fig. 1.

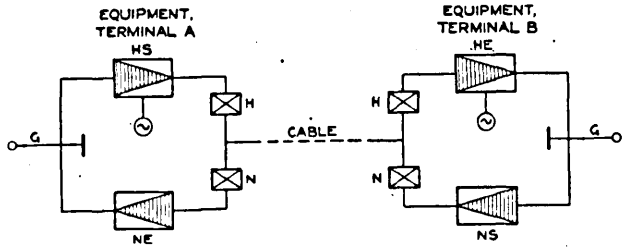


FIG. 1

* The figures given in these instructions correspond to the present state of the technique, and should be considered as being provisional.

For economic reasons use is made in the carrier current path of the lower side band produced by modulation with a carrier frequency; this side band generally is within the band of frequencies effectively transmitted by the cable. The terminal station A includes besides the terminal G, the high frequency transmitter HS which, by modulation, transforms the band of voice frequencies into a band of high frequencies of equal size. Further, the terminal station A includes an incoming low frequency amplifier NE as well as a high pass filter H in series with HS, and a low pass filter N in series with NE. The two filters are so arranged that it is not possible to produce coupling by reaction in the equipment.

The terminal station B includes besides the terminal G, the high frequency receiver HE which transforms the band of high frequencies received into a band of voice frequencies. Terminal station B also includes a low frequency output amplifier NS as well as a high pass filter H in series with HS, and a low pass filter N in series with NS.

2. Possibilities of the application of the two-band telephone system.

The possible application of this system must be considered both from the technical and economic viewpoint.

From the technical point of view it is possible to use two-band telephony if there is available a line able to transmit a band of frequencies large enough to permit the two bands to be passed on the line in different directions. Lines of this class are, for example, open wire lines, light loaded circuits, circuits of new loaded submarine cables, etc. Another condition which must be fulfilled: the crosstalk between circuits taken two by two and the noise due to induced voltages must not exceed the permissible limits. In each particular case these conditions must be fulfilled in circuits in existing cables, or it must be possible to provide them without large additional expense in the case of new connections. Nevertheless technical and economic reasons are opposed to the general introduction of two-band telephony. Two-wire circuits equipped for two-band telephony can only be connected in series if the directions of transmission of the two bands correspond. In order to avoid this restriction for interconnecting, each circuit must be provided with special terminal apparatus for arranging the interconnection at low frequency. To the technical difficulties resulting from repeated modulations and demodulations must be added the great number of terminal stations necessary on relatively short sections of line, and this affects the economic considerations.

As in all carrier current systems, the economic advantage that can be obtained from two-band telephony depends solely on the length of the section of the line. It is necessary to determine if the saving in conductors is greater than the additional expense due to the terminal apparatus. It seems that it can be assumed that the economic and technical conditions justifying the use of two-band telephony will be fulfilled when it is necessary to interconnect, permanently, a certain number of circuits to obtain a direct circuit of great length. This is the case, for example, with direct connections between two distant centres with large traffic. Another case of possible application of two-band telephony is in the case of very long open wire lines with several intermediate repeaters when unstable conditions of the circuit prevent the application of 2-wire circuits.

In the case of submarine cables, the traffic condition per group of circuits is naturally fulfilled. Although it cannot be said that a submarine cable for two-band telephony is always more economical than the corresponding cable for a 4-wire system, it is possible, however, in most cases to obtain a certain economic advantage from the use of two-band telephony.

Further, in a number of cases, two-band telephony allows the use of certain 2-wire submarine telegraph cables of short length for telephone service.

3. **Technical conditions which the terminal apparatus must fulfil.**

(*a*) *Band of frequencies effectively transmitted.*

The band of frequencies effectively transmitted must be at least between 300 and 2 400 p : s for the two directions of transmission. It follows that for the low frequency path the band is included between the frequency F_1=300 p : s and F_2=2 400 p : s and for the carrier current path, the band is between the frequency $F_T - F_1$ and $F_T - F_2$ where F_T is the carrier frequency.

The separating band, that is the band of frequencies between those of the two paths, must be large enough to provide satisfactory stability. This band is recommended up to 1 000 p : s (however it must never be less than 700 p : s). A good distribution of frequencies is as follows :—

Low frequency path	300—2 400 p : s.
Carrier current path	3 400—5 500 p : s.
Carrier frequency	5 800 p : s.

In the case of a wider band effectively transmitted the frequencies could be :—

300—3 000 p : s 4 000—6 700 p : s ; carrier frequency 7 000 p : s.

In special cases the following distribution has given entire satisfaction.

Low frequency path	300—2 350 p : s.
Carrier current path	3 050—5 100 p : s.
Carrier frequency	5 400 p : s.
Cut-off frequency	5 400 p : s.

(*b*) *Carrier frequency.*

The frequency of the carrier current generator must be as constant as possible and must not vary by more than $\pm$ 5 p : s due to exterior influences such as : temperature variation ; replacement of valves; variations in supply voltage etc. The amplitude of the carrier frequency that can be introduced for modulation and demodulation must be constant, and it must be possible to regulate it to a value consistent with a limit of $\pm$ 5 per cent.

(*c*) *Attenuation and Gain.*

(α) **Two-band section including terminals between two toll exchanges.** (*See* **Fig. 1.**)

The output and input amplification must be such that an equivalent of 0.8 néper can be obtained between the two exchanges. Elsewhere the equivalent must fulfil the conditions recommended for 4-wire sections. (*See* Appendix Bd. 2, No. 4.)

The choice of output and input transmission levels depends upon particular conditions, especially in the case of submarine cables.

(β) **Two-band sections consisting of part of a long 4-wire section.**

In this case the terminal stations occupy the position of 4-wire repeaters on the line. Therefore they must essentially fulfil the conditions laid down for 4-wire repeaters. The gain obtained by the terminal station *A* in the high frequency direction is determined by the ratio between the power of the side band to be transmitted and the power of the low frequency applied. Likewise, the gain obtained by the terminal station *B* is determined by the ratio between the power of the low frequency to be obtained and the power of the side band received. As far as possible the gain obtained by the terminal station must, in the two directions of transmission and for all bands transmitted, be equal to the attenuation of the preceding section of cable. However, if the attenuation distortion on the cable using two-band telephony is large it may be advantageous partially to correct this distortion at the output, in the sending amplifier. But the counter distortion realised by the sending and receiving systems together must always be such that, on the 4-wire sections, the output level of the 4-wire section is practically independent of the frequency in all the frequency bands effectively transmitted.

The deviation between the effective gain of each terminal station and the theoretical curve must not exceed $\pm$ 0.2 néper for the carrier path and $\pm$ 0.1 néper for the low frequency path, for all bands of frequency effectively transmitted.

The equipment of the terminal stations must take account of the eventual change in attenuation caused by repairs to the cable.

(*d*) *Regulation of the Gain.*

It must be possible to regulate the gain in steps of 0.1 néper. The total amount of regulation must for each terminal station and for each direction of transmission be equal to 1 néper, that is from — 0.5 néper below to + 0.5 néper above the theoretical value.

(*e*) *Impedance.*

(α) **Two-band section between two toll exchanges.**

The impedance W of the terminal station measured with the line transformers and viewed from the cable side will be approximately equal to the characteristic impedance Z of the cable such that :—

$$2\left|\frac{Z-W}{Z+W}\right| \text{ (twice the reflection coefficient).}$$

should not be greater than 1.2.

The requirements in the specification for the supply of 4-wire terminals must apply equally to the impedance seen from the toll exchange.

(β) **Two-band sections forming part of a long 4-wire section.**

The input and output impedance seen from the 4-wire side must fulfil the condition that the coefficient of reflection be less than 0.4 for the input impedance and 0.6 for the output impedance. At a frequency of 800 p : s the input and output impedances, in the case where there are no toroidal repeating coils must equal 800 ohms (limit 600-950 ohms).

(*f*) *Non-linear distortion.*

If, at a point of the line where the level is equal to zero, the power is changed from 1 mW to 4 mW, for no frequency within the band transmitted should the equivalent of the two-band connection vary by more than $\pm$ 0.1 néper.

(*g*) *Crosstalk.*

Referred to points where the level is the same, the crosstalk between any two installations closed by impedances of 800 ohms should not be less than 8.0 népers.

(*h*) *Conditions imposed upon a complete two-band telephone system.*

On 4-wire sections which include a two-band section, or on sections entirely using two band telephony, the conditions are the same as those for 4-wire sections as regards the *equivalent*, *the levels at frontier stations*, *the echo effects* and *stability*.

APPENDIX B.b.3, No. 1.

ESSENTIAL CLAUSES OF A TYPICAL SPECIFICATION FOR THE SUPPLY OF REPEATERS AND SPECIAL CORRECTORS FOR THE RELAY OF RADIO BROADCAST TRANSMISSIONS.*

General.—The present specification governs the principal conditions which must be fulfilled, from an electrical standpoint, by repeaters when they are accepted in the factory. It does not, however, govern the corresponding conditions after installation.

*The values given hereafter should be considered as provisional.

Type.—The repeater should be equipped with vacuum tubes and give one-way amplification, with a transmission quality maintained within the frequency band to be transmitted, which band, in accordance with the recommendations of the C.C.I., must extend, at least, from a frequency of 50 p : s up to a frequency equal to 0.7 of the cut-off frequency, but in all cases less than 10 000 p : s for a loaded line; for open-wire lines the repeater should be capable of transmitting frequencies up to 10 000 p : s.

Amplification.—The repeater, with all its auxiliary apparatus, should amplify in such a manner as to compensate, as much as possible, for the expected attenuation of the preceding repeater section, as communicated beforehand to the contractor. In the frequency band to be transmitted, therefore, the amplification should increase with the frequency so as to compensate for the distortion produced by the line. For frequencies still lower or still higher, the amplification must not exceed the values given by the amplification curve, which produces a sufficient distortion correction.

The gain should not vary by more than 0.1 néper or 0.87 decibel through the entire band of frequencies to be transmitted when the output power varies from 1—50 milliwatts.

It is necessary to provide for the regulation of the amplification in steps of 0.1 néper or 1 decibel, as a maximum. The amplification curves for the whole frequency band to be transmitted (giving amplification in terms of frequency) must be parallel for all settings of the regulating device.

The variations in voltage at the terminals of the repeater, with a regularly maintained source of current, should give rise to a maximum variation in amplification of 0.03 néper or 0.26 decibel.

Impedance.—Values of the repeater impedance, measured at the input and output terminals, are to be adapted as well as possible to the values of the impedance of the lines which will be connected to the repeater.

Listening Device.—A listening device must be provided, enabling the radio transmission to be monitored before and after the repeater. This device should have a sufficiently high impedance so as not to cause a decrease in the gain (increase in attenuation) of more than 0.03 néper or 0.26 decibel.

Crosstalk.—Crosstalk attenuation measured under operating conditions at the output terminals should be equivalent to at least 10 népers or 87 decibels between two repeaters used for broadcasting, or between one of these repeaters and a repeater to be used for ordinary telephony.

When tests are made, the repeaters should be closed by impedances corresponding to those of the lines to which they will be connected.

Output Power.—The maximum power given out from the repeater and transmitted to the line without distortion should amount to approximately 50 milliwatts. The music or speech volume will be chosen so that it may be possible to use all this power when the largest possible quantities of energy are being transmitted.

Absence of Noise.—The noise level should be less than the maximum level used by at least 9 népers or 78 decibels, which corresponds to a noise voltage of approximately $\frac{1}{8000}$ part of the maximum voltage used.

Non-linear Distortion.—The level of the harmonics produced must be less than that of the fundamental wave by a minimum of 3.2 népers or 28 decibels for the maximum power and for any frequency in the frequency band to be effectively transmitted.

APPENDIX B.c.3, No. 1.

GUIDING PRINCIPLES FOR DRAWING UP SPECIFICATIONS FOR CABLE TERMINALS.

It is not possible to draw up a precise and detailed general specification for cable terminals on account of the numerous types in existence and the different conditions for which they are required.

The following points should particularly be taken into consideration :—

1. The insulation resistance measured with direct current between the terminals shall be large enough to be without effect on the insulation tests made on the cable itself under the most unfavourable humidity conditions met with in practice.

2. Cable terminals shall neither introduce serious unbalances nor add sufficient resistance to have an appreciable effect on the impedance of the circuit.

3. The material of which the cable terminals are made shall withstand all effects of temperature and mechanical stress likely to be met with in practice. The arrangement of the equipment shall be such as to allow easy removal of dust, and convenient manipulation for testing purposes of the terminals to which the circuits are connected.

APPENDIX B.c.3, No. 2.

GUIDING PRINCIPLES FOR DRAWING UP SPECIFICATIONS FOR PROTECTIVE APPARATUS.

Protective apparatus is not generally necessary on circuits which are entirely underground. In special cases where protection is necessary the apparatus used shall not add to the unbalances of the circuit, nor cause any reduction in the insulation of the circuit under the worst working conditions.

APPENDIX B.c.3, No. 3.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF LINE TRANSFORMERS

This Specification concerns transformers to be used on circuits equipped with telephone repeaters.

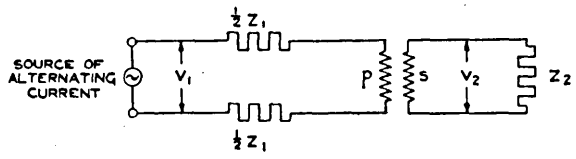
General Clauses.

1. The ratio of transformation shall be such, that when the transformer is connected to the circuits for which it has been designed, the impedance measured at the ends of the windings on the exchange side should be within the limits fixed by the C.C.I. for the uniform value to be given to the impedance of international circuits.

2. For voice frequencies, a line transformer should be characterised by its effective attenuation which is defined above (p. 18). If Z_1 and Z_2 are the impedances connected to the primary and secondary windings respectively (*see* figure below) the effective attenuation b in népers is given by :—

$$\log_e \frac{V_1}{2V_2} - \tfrac{1}{2} \log_e \frac{Z_1}{Z_2}$$

V_1 is the potential measured at the terminals of the A.C. source, V_2 the potential at the terminals of the secondary closed with impedance Z_2; the impedance Z_1 is adjusted to the value given to the impe-



dance of international circuits, that is for a frequency of 800 p : s—a value in general of 800 ohms (or between 600 and 950 ohms); impedance Z_2 is equal to $Z_1 \times U^2$, U being the ratio of number of turns of the primary and secondary windings.

The effective attenuation of the usual line transformer (transformer whose ratio of turns is less than 3) measured in this way and under the conditions corresponding to a transmitter power of 1—50 milliwatts should not exceed 0.08 néper (or 0.7 decibel) for any frequency in the band effectively transmitted.

3. The transformer should be balanced from the point of view of inductance, resistance and capacity in such a manner that the crosstalk between the windings corresponding to side circuits and to the phantom circuit, does not exceed the value corresponding to 8.5 népers or 74 decibels when these windings are connected to perfectly balanced non-inductive resistances representing the lines.

4. The insulation resistance between any two windings or between any winding and the case (or the screen, if a screen is used) shall not be less than 500 megohms when it is measured with a d.c. voltage of 100 volts. The dielectric strength between the winding on the line side and the winding on the exchange side, as well as the dielectric strength between any winding and the case or the screen (if a screen is used), shall be sufficient for these windings to withstand the application of an alternating voltage of 500 volts at a commercial frequency.

In case of proximity between telephone lines and high tension lines the dielectric strength between the two windings and between each of the windings and the case (or screen) shall be such that the transformer can stand an alternating potential of 2000 volts of commercial frequency.*

5. The properties (or constants) of the transformers shall not vary to an appreciable extent under the action of the continuous or alternating currents which occur in practice.

6. Crosstalk between adjacent transformers shall be negligible.

Special Clauses.

7. Transformers designed for use in the line and network circuits of 2-wire repeater installations.

In 2-wire repeatered circuits, when a transformer is inserted on the line side and another transformer is inserted on the network side, these two transformers shall be selected in pairs, in such a way that the vector impedance measured at the terminals of the winding on the repeater side for any frequency within the band of frequencies to be transmitted and under normal working conditions shall be the same within approximately $\pm$ 2 per cent., whatever may be conditions of current, temperature, etc., occurring in practice.

8. Transformers designed to transmit signalling currents at a low frequency of about 16 to 25 p : s.

For these frequencies, the line transformer should be characterised by its energy efficiency, which can be measured in accordance with either of the methods described in the Addendum. In order to compare transformers among themselves, the energy efficiency is measured by closing the line side of the transformer through an impedance of 2000 ohms $\underline{/0}$ and applying an e.m.f. of 45 volts ($\pm$ 3) to the terminals of the office side of the transformer. The energy efficiency should not be less than 55 per cent.

ADDENDUM TO APPENDIX B.c.3, No. 3.

Measurement of the energy efficiency of line transformers used for low frequency signalling, 16 to 25 p : s.

METHOD 1.—Method based upon the use of a wattmeter.



* The attention of the C.C.I.T. is drawn to the fact, that infra-acoustic telegraph installations connected direct to cables should be subject to dielectric breakdown conditions, similar to those imposed on line transformers in case of proximity between telephone lines and high tension lines. In cases where the C.C.I.T. considers it of importance to study this question, the 1st C.R. of the C.C.I. will collaborate in this study.

Explanation :—The energy efficiency is equal to the ratio

$\frac{L_2}{L_1}$, L_1 being the power measured at the input of the transformer and L_2 the power measured at the output.

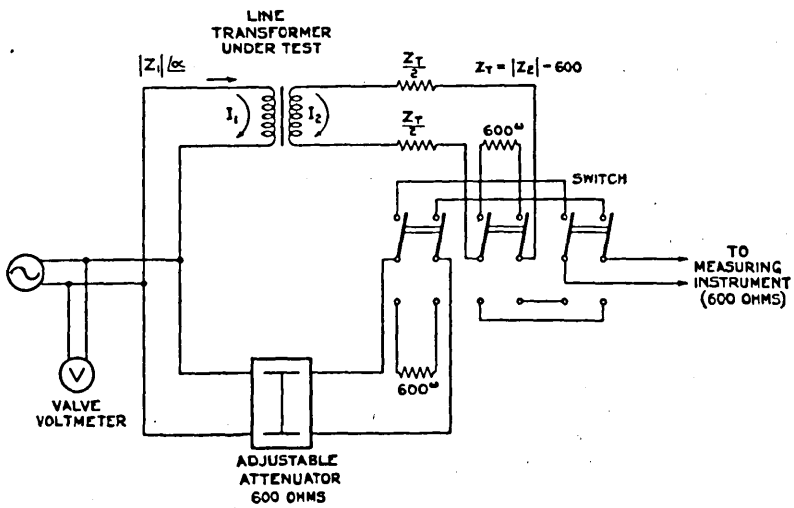
$L_1 = L'_1$ (power as read) $- \frac{V_1^2}{r_{sp}}$ (power absorbed by the wattmeter)

$$L_2 = J_2^2 (R+r) \text{ or } \frac{V_2^2}{R}$$

In the diagrams V_1 and V_2 are electrostatic voltmeters.

In the formula, V_1 and V_2 and J_2 designate the voltages or the effective intensities and R represents the effective resistance.

METHOD 2.—Method based upon the case of a variable attenuator.



The energy efficiency of a line transformer is defined by the ratio between the power (in watts) obtained at the output and the power (in watts) applied at the input of the line transformer.

If $| Z_1 | \angle \alpha$ represents the impedance at the input of the transformer when an impedance $Z_2 \angle \beta$ is connected to the output, the energy efficiency, as defined above, is :—

$$\eta = \frac{i_2^2 | Z_2 | Cos\ \beta}{i_1^2 | Z_1 | Cos\ \alpha}$$

Where i_1 and i_2 represent respectively the currents at the input and output of the transformer (*see* above).

It is easy to measure the impedance $| Z_1 | \angle \alpha$ at low frequencies by means of a Maxwell bridge, the measuring instrument being a vibrating galvanometer. The galvanometer should be tuned at the frequency at which the measurements are made. The harmonics of the supply current will produce an enlargement of the luminous spot on the screen, but the measurements are sufficiently accurate if based upon the minimum size of the spot.

$| Z_2 | \angle \beta$ is connected at the output of the transformer, the voltage at the terminals of the transformer having a value corresponding to voltages used in practice.

The factor $\frac{Cos\ \beta}{Cos\ \alpha}$ can be calculated.

The other factor $\frac{i_2 | Z_2 |}{i_1 | Z_1 |}$ is obtained by means of measurements made with the arrangement above.

By means of the variable attenuator, the current at its output is varied until it is equal to the current at the output of the line transformer. The voltage at the input terminals of the attenuator is equal to the voltage at the input terminals of the transformer and it is made equal to the voltage at the terminals of the transformer during the impedance measurements.

If A is the value read on the attenuator when a balance is obtained, the following can be written :—

$$A = 10\ log_{10} \frac{(i_1 |Z_1|)^2}{(i_2 \times 600)^2} = 10\ log_{10} \frac{i_1^2 |Z_1|}{i_2^2 |Z_2|} \times \frac{|Z_1| \times |Z_2|}{(600)^2}$$

A $|Z_1|$ and $|Z_2|$ are known $\frac{i_1^2 |Z_1|}{i_2^2 |Z_2|}$ can be calculated, and consequently the energy efficiency η.

APPENDIX B.c.4, No. 1.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF TWO-WIRE TELEPHONE REPEATERS.

General.—This specification covers the more important electrical requirements concerning the essential qualities of the repeater units as supplied by the factory. It does not cover the requirements for installed repeaters.

Type.—It shall be a 2-valve vacuum tube repeater, generally equipped with filters and using balancing networks. It shall give 2-way amplified transmission without introducing appreciable non-linear distortion for all frequencies within the efficient speech ranges of the cable circuits and for the maximum inputs occurring in practice.

Balance.—The repeater shall not " sing," *i.e.*, it shall not generate oscillations which cause singing at maximum gain, when the circuit and network terminals on either side are closed through non-reactive resistances, equal to the input impedance specified for the repeater; whilst the circuit and network terminals on the other side are open and short circuited, respectively, or vice versa.

Amplication.—In order that the whole circuit shall fulfil the recommendations of the C.C.I., it may be necessary that the repeaters used shall be designed to compensate for the distortion due to the line. In that event the gain of the repeater should vary with the frequency within the band of frequencies, for which the circuit is to give a good performance. At the highest frequencies the gain should decrease in such a manner that it completely vanishes in the neighbourhood of the cut-off frequency of the circuit. At the lowest frequencies the gain should not exceed the values of a gain characteristic, which will give an exact anti-distortion effect.

Means shall be provided for regulating the gain of the telephone repeater, preferably by steps not exceeding 0.1 néper or 1 decibel.

The gain frequency curves shall be parallel in the band of frequencies which the cable transmits efficiently for all repeater settings.

The repeater circuit and apparatus shall be so designed that, with normal maintenance conditions of the power supply, variations in the supply voltage and current shall not produce a maximum variation in the gain of the repeater in service greater than 0.05 néper or 0.4 decibel.

The maximum gain variation of a repeater inserted in very long circuits (more than 12 repeaters being used) should not exceed 0.03 néper or 0.3 decibel. In order to bring this about, it is recommended that automatic regulators be used on the filament and plate batteries.

Impedance.—The impedance of the repeater, including the line transformers, shall be approximately equal to that of the circuit upon which the repeater is placed in service so that:—

$$2\left|\frac{\zeta - w}{\zeta + w}\right|$$

shall be a maximum of 0.4 for the whole band of frequencies efficiently transmitted by the repeater, ζ being the characteristic impedance of the line, w the impedance of the repeater measured as follows:—

The impedance of the repeater is measured under working conditions using the networks but suppressing reaction effects, *e.g.*, to measure the impedance of side X of the repeater, the circuit of side Y is replaced by a balancing network: the balancing network of side X shall reproduce the circuit of side X which is replaced by the measuring set; the potentiometer of the direction X—Y shall remain on the normal service position and the transmission is suppressed in the direction Y—X.

Monitoring.—Means should be provided so that it is possible to monitor on the circuits in either or both directions with an operator's telephone set, and to talk on the circuits when necessary.

When monitoring on a repeater inserted in the circuit (for the silent position), the losses caused by the monitoring device shall not exceed 0.03 néper or 3 decibels.

Crosstalk.—When repeater units, mounted either side by side or one over the other, are operated by batteries, as in practice, the crosstalk between the units measured on the output side shall not be less than 8 népers or 70 decibels, on the understanding that when these measurements are being carried out the repeaters will be joined to impedances having a value equal to that of the uniform impedance fixed for international circuits.

Non-linear Distortion.—The co-efficient of non-linear distortion (Klirrfaktor), that is the ratio between the square root of the sum of the squares of the effective values of the harmonics introduced by the non-linear distortion and the effective value of the fundamental, should not exceed 5 per cent. for the frequency of 800 p:s and for a maximum power equal to 20 mW in the case of a 2-wire circuit and 50 mW for a 4-wire circuit, the voltage of the battery supply to the filament and plate of the valves of the repeater being normal and the grid being always at a negative potential to the filament; the line transformers do not form part of the measuring circuit and the repeater has a non-inductive resistance of 600ω connected to the output during test. (The value 5 per cent. is provisional; it is valid until the maximum permissible value for the co-efficient of non-linear distortion has been fixed.)

Note.—The above definition of co-efficient of non-linear distortion is provisional.

Further, the C.C.I. propose fixing provisionally in the different cases the maximum power measured at the output of a repeater, as follows:—

Repeaters for 2-wire circuits in cable	20 mW
Repeaters for 4-wire circuits in cable	50 mW
Repeaters for 2-wire open-wire circuits...	20 mW
Repeaters for Voice Frequency Carrier Telegraph	50 mW

APPENDIX B.c.4, No. 2.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF FOUR-WIRE TELEPHONE REPEATERS.

General.—This Specification covers the most important electrical requirements concerning the essential questions pertaining to telephone repeater units as supplied by the factory. It does not cover the requirements for installed repeaters.

Type.—It shall be a valve repeater and shall give one-way amplified transmission without appreciable distortion for all frequencies within the efficient speech range of the cable circuits with which it is associated, and for the maximum inputs occurring in practice.

Amplification.—The amplification produced by the repeaters shall vary with frequency within the frequency range efficiently transmitted by the cable so as to compensate sufficiently for the distortion introduced by the line. For the lower and higher frequencies, the amplification shall not exceed the values of an amplification curve which would produce an exact compensation.

Means shall be provided for regulating the gain of the telephone repeater, preferably by steps not exceeding 0.1 néper or 1 decibel. In the case of very long circuits, it may be necessary to provide an adjustment by steps not exceeding 0.03 néper or 0.26 decibel.

The gain frequency curves shall be parallel in the band of frequencies which the circuit transmits efficiently for all repeater settings.

The repeater circuit and apparatus shall be so designed that, with normal maintenance conditions of the power supply, variations in the supply voltage and current shall not produce a maximum variation in the gain of the repeater in service greater than 0.05 néper or 0.4 decibel.

The maximum gain variation of a repeater inserted in very long circuits (more than 12 repeaters being used) should not exceed 0.03 néper or 0.3 decibel. In order to bring this about, it is recommended that automatic regulators be used on the filament and plate batteries.

Impedance.—The impedance of the repeater, not including the line transformers, will be approximately equal to that of the circuit with which this repeater will be in service such that:—

$$2\left|\frac{Z-w}{Z+w}\right|$$

is, at a maximum, equal to 0.8 for the input impedance of the repeater and 1.2 for the output impedance, Z being the impedance of the line (including line transformer) and W the impedance of the repeater; these figures should not be exceeded for any frequency of the band transmitted.

Monitoring.—Means shall be provided so that it is possible to monitor on the lines in either or both directions with an operator's telephone set, and to talk on the circuit when necessary.

When monitoring on a repeater inserted in a circuit the losses caused by monitoring shall not exceed 0.03 néper or 0.26 decibel.

Crosstalk.—With repeater units mounted either side by side or one over the other and operated by batteries, as in practice, the crosstalk between units, measured between the outgoing terminals, shall not be less than 8 népers or 70 decibels, on the understanding that, when these measurements are being carried out, the repeaters will be joined to impedances having a value equal to that of the uniform impedance fixed for international circuits.

Non-linear Distortion.—The co-efficient of non-linear distortion (Klirrfaktor), that is the ratio between the square root of the sum of the squares of the effective values of the harmonics introduced by the non-linear distortion and the effective value of the fundamental, should not exceed 5 per cent. for the frequency of 800 p:s and for a maximum power equal to 20 mW in the case of a 2-wire circuit and 50 mW for a 4-wire circuit, the voltage of the battery supply to the filament and plate of the valves

of the repeater being normal and the grid being always at a negative potential to the filament; the line transformers do not form part of the measuring circuit and the repeater has a non-inductive resistance of 600ω connected to the output during test. (The value 5 per cent. is provisional; it is valid until the maximum permissible value for the co-efficient of non-linear distortion has been fixed.)

Note.—The above definition of co-efficient of non-linear distortion is provisional.

Further, the C.C.I. propose fixing provisionally in the different cases the maximum power measured at the output of the repeater, as follows :—

Repeaters for 2-wire circuits in cable	20 mW
Repeaters for 4-wire circuits in cable	50 mW
Repeaters for 2-wire open-wire circuits...	20 mW
Repeaters for Voice Frequency Carrier Telegraph	50 mW

APPENDIX B.c.4, No. 3.

GUIDING PRINCIPLES TO BE OBSERVED IN THE SETTING UP OF SPECIFICATIONS FOR POWER PLANTS.

The C.C.I. draws the attention of Administrations to the following points :—

1. In view of the necessity of keeping an uninterrupted service on international circuits, power plants must be provided so that it is possible to overcome interruptions of the normal source of power.

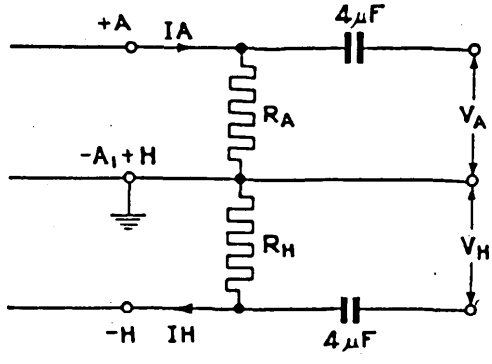
2. It is necessary, on the other hand, that the entire installations should be sufficiently free from disturbance, so that the disturbing voltage produced at the repeater output does not exceed the provisionally fixed maximum of 2 millivolts at zero level.

(*See* " Guiding principles concerning measures to be taken in order to protect telephone lines against the disturbing influences of heavy-current or high-tension power lines," published by the C.C.I. 1930.)

3. In the case of repeater stations provided with D.C. plant (accumulators, rectifiers) supplied by a manufacturer other than the firm supplying the repeater equipment, the noise voltage, measured from the repeater racks at the ends of the D.C. busbars should not exceed the following provisional values :—

2·4 mV for the filament supply.
220 mV for the plate supply.

To measure this noise voltage the arrangement indicated below is used.



On the fuse panel the battery is not connected to the repeaters, but to resistance calculated to take the maximum current of the installation. The direct current cannot pass the two 4μF condensers and the noise voltages *VH* and *VA* are measured by suitable apparatus.

APPENDIX B.c.4, No. 4.

GUIDING PRINCIPLES AS A HELP TOWARD THE ESTABLISHMENT OF ESSENTIAL CLAUSES OF A SPECIFICATION FOR VOICE FREQUENCY RINGERS.

Sensitivity.—The receiving apparatus shall operate correctly at a transmission level equal to the nominal level of the circuit at the place where it is installed, when the calling station sends a current of the frequency and voltage in accordance with the recommendations of the C.C.I., and when the level differs by $\pm$ 0.5 néper (or 4.3 decibels) from the nominal level.

The receiving apparatus shall operate correctly on a signal, the duration of which does not exceed 0.8 second; it shall not be operated by normal speech currents on the circuit to which it is connected.

Loss.—The transmission loss introduced into the circuit by the receiving apparatus shall not exceed 0.035 néper or 0.3 decibel at all frequencies in the range efficiently transmitted by the circuit.

APPENDIX B.c.4, No. 5.

GUIDING PRINCIPLES TO BE OBSERVED IN THE ESTABLISHMENT OF SPECIFICATIONS FOR BALANCING NETWORKS FOR TWO-WIRE REPEATERS.

The balancing networks shall be constructed to simulate the circuit impedance as accurately as possible for the range of frequencies efficiently transmitted by the repeater.

On the other hand, they shall be so constructed that their impedance does not vary appreciably with time, variations of current, temperature and humidity met with in practice.

APPENDIX B.c.4, No. 6.

GUIDING PRINCIPLES TO BE OBSERVED IN THE ESTABLISHMENT OF SPECIFICATIONS FOR ECHO SUPPRESSORS.

The echo suppressors shall be of a type which increases the loss in the return circuit of a four-wire system when the echo circuit is working at normal level, so as to suppress the echo.

It shall be designed so that the time necessary for the introduction of loss in the return circuit shall be less than the time of travel of the echo, and the time necessary to return to normal shall be greater than the time of travel of the echo.

Means shall be provided to adjust these two times in accordance with the echo conditions of the circuit.

The suppressor shall not introduce a transmission loss greater than 0.06 néper or 0.5 decibel on the talking circuit.

Further, the suppressor installation shall neither appreciably increase the crosstalk between different circuits, nor diminish the stability of the circuit.

APPENDIX B.c.4, No. 7.

GUIDING PRINCIPLES FOR THE SETTING UP OF ESSENTIAL CLAUSES IN A TYPICAL SPECIFICATION FOR THE DELIVERY OF TERMINATING EQUIPMENT.

1. The terminating equipment must be of a differential type.

2. Echo attenuation of the terminating equipment must not be less than 6 népers in the frequency band to be transmitted, when the two sets of terminals of the terminal equipment labelled "line" and "network" are connected to two ohmic resistances of 800 ohms.

3. The effective attenuation of the terminating equipment in the direction 4-wire to 2-wire circuit, and vice versa, must not exceed 0.5 néper (4.3 decibels) at 800 p : s.

4. The impedance measured at each of the four terminals of the terminating equipment must have a value lying between 600 and 950 ohms (uniform value of the impedance of international circuits and of the repeaters) when the three other sets of terminals are closed by ohmic resistance of 800 ohms. It is desirable that the impedances be as independent as possible of the frequency.

5. The terminating equipment of a light loaded 4-wire circuit must include at least a low pass filter or an equivalent device having a cut-off frequency of 3 000 p : s and filtering currents coming from the 4-wire circuit.

APPENDIX B.c.4, No. 8.

GUIDE TO THE SETTING UP OF SPECIFICATIONS OF REPEATER STATION INSTALLATIONS WITH RESPECT TO TESTING AND MEASURING APPARATUS.

1. Apparatus used for the Testing and Measuring of Insulation.

A. These instruments should be slightly under-damped in order to allow the needle to over-swing so as to ensure accuracy in the readings.

The period of the instruments should be as small as possible, considering the other characteristics of the instruments, so that the reading can be readily taken.

B. The instruments should allow insulation to be measured :—

(*a*) Over a range of 1 to 1 000 megohms for accurate measurements made by the cable repair service (periodic special tests and measurements in case of faults).

(*b*) From 0·1 to 15 megohms at least for periodic maintenance measurements.

(*c*) For readings not exceeding 100 megohms the accuracy of measurement should be ± 10 per cent.

C. These instruments should not require a higher voltage than 600 volts.

D. These instruments should give a constant deviation for a circuit having capacity when the source of measuring current used is provided manually.

E. In any case, the line current provided by the instrument must not exceed 100 mA.

The instruments will therefore be provided with protecting resistances which will limit the charging and discharging currents of the cable and the normal line measuring current to 100 mA.

2. Instruments for the Testing and Measuring of Resistance.

A. Conductor resistances and others smaller than 100 000 ohms.

1. The instruments must permit the resistance measurements to be made with the following accuracy :—

From 1 to 10 000 ohms. Test accuracy ± 0·1 per cent.
From 10 001 to 100 000 ohms. Test accuracy ± 1 per cent.

2. For rapid and qualitative tests a voltmeter device can be used giving a 10 per cent. accuracy up to at least 100 000 ohms.

3. It is to be recommended for resistance measurements not to use too high voltages which could momentarily reduce a fault. It would be desirable to make tests with a tension less than 150 volts and, if the sensitivity of the bridge will allow it, the voltage should not exceed 50 volts.

B. Resistance Unbalance of Line Conductors.

1. The bridge used must provide an easy and accurate means of measuring the unbalance, equal to about 0·05 per cent. of the mean resistance between the two branches of a circuit.

2. It is desirable in certain cases of resistance unbalance to utilise 0·5 to 4 volts.

C. Localisation of Faults on Lines by means of Resistance Measurements.

1. Depending on the accuracy required, the zero instruments employed will be either mirror galvanometers or needle galvanometers; their sensitivities should be such as to allow currents of 10^{-7} amps to be measured.

2. The calibrating resistances of the bridge must have the following accuracy:—

Resistances of the arms of the bridge: 0·01 per cent.

Resistances of the regulating rheostat from 0 to 99: 0·03 per cent., provided that an absolute precision of less than 0·005 ohm is not required; from 100 to 10 000: 0·02 per cent.

These accuracies include errors due to contact resistances of the switches in the bridge.

3. The tension for localising measurements must be sufficiently high to avoid the influence of stray currents and sufficiently low to prevent large line currents. It is advisable not to exceed 600 v.

4. The attention of the Administrations and Operating Companies should be called to the advantage of being able to localise according to the Varley and Murray methods with the possibility in each case of reversing the connections of line with respect to bridge and with the advantage of being able to measure, taking ground or a cable conductor as the third wire.

5. In the various preceding cases, A, B and C it will be necessary to limit the output line current in the bridge to a maximum value of 100 mA.

6. In order to increase the speed of measurements and the operating accuracy the instruments must be slightly under-damped, in order to permit of an over-swing of the needle.

The period of the instruments must be as short as possible, considering the other characteristics of the instruments, so that the readings can be readily taken.

3. Instruments for the Measurement of Equivalent and of Levels.

(Hypsometers, Transmission Measuring Sets, and Pegelmeszgeräte.)

A. Generator used in conjunction with Transmission Measuring Set.

(*a*) **Power.** In the band of frequencies used, and taking into account the variations of the supply, the generator should supply sufficient power so that the output network of the level measuring set under normal conditions of delivery has an output of at least 1 mW.

The normal conditions refer to a sending network of internal resistance of 600 ohms ± 2 per cent., connected to a resistance of 600 ohms.

(*b*) **Accuracy of Frequency.** The frequency used for the transmission measurements should be capable of regulation with an accuracy of at least 2 per cent.

(*c*) **Harmonics of the Measuring Current.**

(α) For all types of loading occurring in practice and for the range of frequencies employed, the proportion of the harmonics (ratio of voltages) must be less than $\frac{5}{100}$ of the fundamental.

(β) When an indicating device is used, such as an instrument consisting of a rectifier which rectifies half an alternation of the current only, the deviation of the test results due to harmonics in the generator when the polarity of the input terminals is reversed should be smaller than 0·02 néper or 0·2 decibel.

(*d*) **Band of Frequencies used:—**

(α) For stations dealing with circuits used for broadcast transmissions, from 50 to 10 000 p : s.

(β) For all other stations, at least 200 to 2 800 p : s.

(γ) For stations using telephone installations of high frequency carrier currents, a range of frequency including all frequencies to be transmitted.

(*e*) The **power** provided by the generator must be as independent as possible of the variation of frequency.

(*f*) **Stability of the Frequency.** The frequency must not vary by an appreciable amount with the power supplied, nor must it be influenced by the variations of the supply voltages which occur in practice.

When these conditions are fulfilled, the tuning device may be calibrated directly by means of a calibrating table into periods per second, and it will not be necessary to use a harmonic frequency meter.

B. Transmission Measuring Set.

(*a*) **Output Power.** The output power of a level measuring set must be capable of regulation to 1 mW with an accuracy of ± 3 per cent. The internal resistance of the output network as seen from the line terminals must be 600 ohms ± 2 per cent.

(*b*) **Accuracy of the Terminal Resistances for Measurements of Equivalents.** The receiving network should be such that when seen from the line terminals it offers a resistance of 600 ohms ± 2 per cent.

(*c*) **Accuracy of the Measurements.** The accuracy of the measurements must be within 0.02 néper when the same instrument is used for receiving and sending.

(*d*) **Graduations.** The level measuring set must be graduated in " népers " or in " decinépers " or in " decibels " in steps not exceeding 0·05 néper or 0·5 decinéper or 0·5 decibel.

(*e*) **Testing Range.** This must cover a range of from +2 to −3·5 népers, or from +20 to −35 decinépers, or from +20 to −30 decibels.

(*f*) **Input Impedance.** The modulus of the input impedance of the Transmission Measuring Set when measuring levels must be greater than 100 000 ohms over the whole band of frequencies used.

(*g*) **Symmetry.** When the terminals of the output of the sending device and of the receiving device of the Transmission Measuring Set are interchanged, the deviation can vary as a result of the harmonics of the output voltage or of the unbalance of the measuring set; this variation must be less than 0·02 néper for the whole of the band of frequencies to be transmitted.

(*h*) **Carrying out of Tests.** The instruments must permit of visual readings.

(*i*) **Variation of the Sensitivity* with Frequency.** For the whole of the band to be transmitted it is desirable that the sensitivity be as far as possible independent of frequency.

C. Recording Level Measuring Sets (automatically recording relative levels at various frequencies).

Subject to final and more complete specifications the recording level measuring sets recommended for use on circuits transmitting radio programmes should meet the following requirements :—†

(*a*) Frequency band : from 30 to 10 000 p : s.

(*b*) Relation between frequency and time :

from 0 to 100 p : s, linear function.
from 100 to 10 000 p : s, logarithmic function.

(*c*) Emission period of one octave within the band 100 to 10 000 p : s, 15 seconds; between 0 and 100 p : s 21·5 seconds.

(*d*) Method of identifying frequencies at the receiving station : a signal is sent out from the transmitting stations 6·5 seconds before a test frequency is applied to the line.

The characteristics of this signal are :—

frequency :	1 300 p : s.
duration of signal :	1·5 seconds
sending voltage :	0·775 volt.

(*e*) Impedance of generator : 600 ohms.
Power delivered into 600 ohms : 1 mW.

4. Special Apparatus for Measuring Gain—(Gain Measuring Sets—Kerdomètres—Verstärkungsmessgeräte).

A. Generators for Gain Measuring Sets.

These generators should fulfil the same conditions as the generators for Transmission Measuring Sets as regards the band of frequencies, the accuracy of the frequency and the proportion of harmonics. They should, in addition, satisfy the conditions relating to power supply of Gain Measuring Sets.

* The sensitivity is the deviation of the needle in mm for a variation of 0·1 néper or 1 decibel in the artificial line.
† *See* also p. 86.

B. Gain Measuring Sets.

(*a*) **Input Voltage.** When making gain tests the voltage applied to the repeater should be kept constant in frequency and in intensity. This voltage should correspond approximately to the mean input voltage, under normal service conditions; it should be regulated in order not to overload the repeater under test, *i.e.*, the output power level of this repeater must not exceed 0·6 néper or 5·2 decibels for a 2-wire repeater, 1·1 népers or 10 decibels for a 4-wire repeater.

The resistance of the output circuit of the Gain Measuring Set as seen from the repeater should be equal to the nominal impedance of the repeater (lying between 600 and 950 ohms at 800 p : s to within at least 5 per cent.).

(*b*) **Output Voltage.** The output voltage should be measured at the terminals of a resistance having a value equal to the normal value of the impedance of the repeater. The resistance of the receiving circuit of the Gain Measuring Set, as seen from the repeater, should not deviate from this nominal impedance by more than 5 per cent.

(*c*) **Accuracy of the Measurements.** The measurements should be accurate to at least 0·05 néper or 0·5 decibel.

(*d*) **Variation of the Deviation when the Polarity of the Testing Instrument is reversed.** The effect of the harmonics in the output current and of the unbalance of the measuring device, should not introduce a deviation greater than 0·02 néper or 0·2 decibel for all frequencies in the frequency band employed.

(*e*) **Graduations.** The Gain Measuring Sets should be graduated in népers, decinépers or in decibels in steps not exceeding 0.05 néper, 0·5 decinéper or 0·5 decibel.

(*f*) **Testing Range.** This interval should be adapted to the nominal value of the gain of the repeaters for the different gain settings.

(*g*) **Variation of the Sensitivity with Frequency.** Refer to corresponding recommendations relating to Transmission Measuring Sets (3B.i.).

5. Instruments for Measuring the Impedance of Circuits.

A. Generators for these Instruments.

(*a*) **Power.** The generators should give an output of 10 mW into all possible line impedances at the various frequencies of the band employed. The power applied to the line should be controlled and regulated by a suitable device.

(*b*) **Accuracy of the Frequency.** The frequency employed for the measurement of the impedance should permit of regulation to within ± 5 cycles per second for frequencies below 2 000. The accuracy for higher frequencies should be at least ± 0·5 per cent.

(*c*) For the other conditions, *see* under 3A*c*, *e* and *f*.

B. Impedance Measuring Apparatus.

(*a*) Possibility of regulating the output of the measuring set: refer to 5A*a* above.

(*b*) **Test Range.** With respect to the measurement of the impedance of normal lines it should be possible to measure the effective resistance up to at least 10 000 ohms and the reactance from − 5 000 to at least + 500 ohms.

It is advisable that the apparatus shall be used to measure the impedance of the different parts of installations; in this connection it is advisable to take into account the possibility of measuring impedances having moduli of 0 to 10 000 ohms and angles of − 90° to + 90°.

(*c*) Accuracy of impedance measurement: ± 0·5 per cent.

6. Instruments for the Measurement of Crosstalk—Crosstalk Meters.

A. Generators for Crosstalk Measuring Sets.

The generators must be capable of supplying a power up to 10 mW to the line. In addition, they must fulfil the conditions referred to under 3 A*b*, 3 A *c*, 3 A *d*β, 3 A *e*, and 3 A *f*.

B. Crosstalk Measuring Sets.

(*a*) The normal output power must be approximately 1 mW. It is desirable however to provide for a power up to 10 mW, where noise on the line makes testing difficult.

(*b*) **Graduation.** The crosstalk meters should be graduated in "népers," "decinépers" or "decibels," in steps of at least 0·5 néper, 5 decinépers or 5 decibels.

(*c*) The testing range should lie between 5 and 11 népers. In special cases (for instance, for broadcast circuits and submarine cables) it will be necessary to provide a wider testing range up to about 15 népers.

(*d*) Terminal resistances.

(α) When measuring circuits from the office side of the repeating coils the terminal resistances should be (600 to 950 ohms) within ± 5 per cent.

(β) When measuring circuits without repeating coils the terminal resistances of the circuit should be matched to the terminal impedance with an accuracy of ± 20 per cent. In the case of side circuits and phantom circuits, the branch resistances forming the phantoms must be such that the condition under (*f*) is fulfilled.

(*e*) **Input Resistance of the Receiving Network.**

(α) It should be (600 to 950 ohms) ± 20 per cent. for tests which include repeating coils.

(β) For tests without a repeating coil the error introduced by the inaccuracy of the matching of the receiving network the circuits and the terminating resistances should not exceed 0·1 néper or 0·87 decibel.

(*f*) Crosstalk in the crosstalk meter and in the terminal networks must be better than the maximum crosstalk attenuation which the instrument can measure by more than 2 népers (or 17·3 decibels).

(*g*) Method of tests. The crosstalk tests should be made by audible comparison or by visual means.

7. Instruments for the Measurement of Noise.

The conditions which these instruments have to fulfil are given in the Appendix to the recommendations of the C.C.I., entitled "Instruments for Objective Noise Measurements."

8. Valve Rejection Tests.

A. Method of Testing.

To make these tests the following devices are necessary; either:—

(*a*) A special device which can be inserted in the filament circuit of any repeater, and which will allow the measurement of gains at limiting values and at the mean value of the filament current; or

(*b*) Special amplifiers whose supply voltages can be varied within the normal limits.

The gains should be measured on the ordinary Gain Measuring Set of the station.

B. Applied Voltage.

The voltages applied to the tubes under test should correspond to the mean voltage used in normal service.

9. Installations permitting of Checking the Battery Voltages and Current Intensities.

A. For Installations in Service.

The voltages and supply currents of repeaters should be easily measurable. Devices should be available which will indicate variations exceeding the permissible limits.

B. Accuracy of the Tests of Current and Voltages.

The test of plate, filament and grid voltages should be made with an accuracy of at least ± 2 per cent.

10. General Conditions which must be fulfilled by all Testing Instruments. Absence of Noise.

A. Influence of Measuring Current Supplies on the Batteries.

The disturbing voltages induced in the batteries by the testing generators must not exceed the permissible limits given for such cases (maximum limit of 2 mV at zero level—Appendix B.c.4, No. 3).

B. **Influence of Battery Noise on Testing Installations.**

The testing installations should work with accuracy as long as the disturbing voltages produced in the direct current supplies and the variation in the voltage supplies do not exceed the fixed limits.

C. **Mutual Disturbing Influences of Testing Apparatus.**

These influences should not be appreciable.

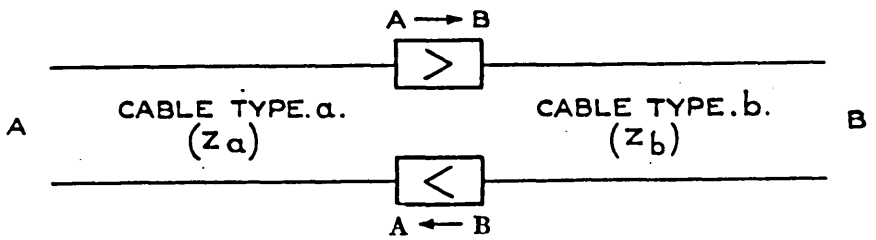
APPENDIX B.c.4, No. 9.

GUIDE TO ESSENTIAL CLAUSES OF A TYPICAL SPECIFICATION RELATING TO THE PROVISION OF REPEATERS FOR THE JUNCTION POINTS BETWEEN TWO CABLES WHICH DIFFER ONE FROM THE OTHER BY THEIR TRANSMISSION PROPERTIES.

1. The said repeaters must fulfil the conditions given in the typical specification concerning the provision of 2-wire and 4-wire repeaters.

2. There are various ways of fulfilling these conditions in the case of 4-wire repeaters.

(*a*) If it is assumed in principle that the repeater must compensate for the attenuation of the preceding repeater section over the required frequency band, repeaters which correct the attenuation distortion by a different amount in the two directions of transmission must be used.



The gain curve of the repeater A—B (*see* Fig. above) must correspond to the attenuation curve applying to the cable type *a*, when the latter is terminated at the input side by an impedance Z_a, which is the impedance of cable *a*, and at the output side by Z_l, which is the impedance of cable *b*. It is exactly reversed for repeater B—A. The application of this principle when various types of cables exist in a country involves installation of a relatively large number of types of repeaters which must be specially provided for this purpose.

(*b*) If for repeater A—B a normal repeater is used of the type which is employed in the installation of a circuit constructed uniformly according to cable type *a*, and in the same manner for repeater B-A, a normal repeater suitable for cable type *b*, the normal gain curve is deviated from, due to the fact that repeater A-B is terminated on the output side by the impedance of the cable type *b* instead of being normally terminated by that of cable type *a*, which produces an additional attenuation.

For instance :—

Z_a is the impedance of cable *a*.

Z_b is the impedance of cable *b*, and

Z_v is the impedance of the repeater

$$K_1 = \frac{Z_a}{Z_v} \quad K_2 = \frac{Z_b}{Z_v}$$

and the additional attenuation therefrom

$$b = \tfrac{1}{2} \log_n \frac{K_2 (1 + K_1)^2}{K_1 (1 + K_2)^2}$$

This attenuation is of the order of several tooths of a néper in all practical cases, and can therefore be neglected. It is therefore possible to reduce the types of repeaters considerably more than if the principles indicated under (*a*) were applied.

(*c*) If the transmission qualities of the existing cable types are similar with respect to the impedance and the attenuation, there is no necessity for a different correction for the two directions of transmission. In this case it is practicable to draw, in addition to the attenuation curves for the existing cable types, a mean curve, to which the repeaters in the two directions must be matched. It is necessary here to distinguish between medium-heavy and light loaded circuits, as their attenuation curves are systematically different. It is thus possible to reduce the number of junction repeater types to be employed to two.

(*d*) Another method consists in using repeaters with variable regulation, thus enabling the most favourable gain curve to be obtained for each direction of transmission.

3. The 2-wire repeaters inserted between two cable sections having different cut-off frequencies must be equipped with low pass filters calculated for the lower one of the two cut-off frequencies; the gain curve must correspond to an attenuation curve which is the mean of the two curves measured between the two adjacent sections.

APPENDIX B.d.2, No. 1.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION GENERALLY APPLYING TO FACTORY LENGTHS OF INTERNATIONAL TELEPHONE CABLES OF THE QUADDED TYPE.

General.*—This specification covers the electrical requirements which must be fulfilled by factory lengths of air-space paper-insulated lead-covered cables for long distance telephone circuits. These requirements are specified in order to ensure that the cables will be suitable for :—

1. Phantom working.
2. Loading of pair and phantom circuits.
3. Efficient long-distance working in conjunction with repeaters.
4. Efficient broadcast transmission over long distances by means of specially screened circuits.

These requirements do not apply :—

1. To cables in which the conductors are smaller than eight-tenths (0·8) of a millimetre (approximately 16 lb. per mile).
2. To groups of one gauge of conductors of less than ten (10) quads.
3. When the total number of circuits of each gauge specified is such that the lay-up of the cable is necessarily unsymmetrical, or such that conductors of different gauges are required to be in the same layer.

Some of the more important raw material requirements are also specified.

Raw Materials.

Copper Conductors.—Each conductor shall consist of a wire of pure, annealed copper, smoothly drawn, cylindrical, uniform in quality and resistance, free from scales or other defects and having a conductivity at least equal to that specified by the International Electro-technical Commission (Berlin, 1913), that is, one fifty-eighth ($\frac{1}{58}$) of an ohm for the resistance of a wire of standard annealed copper one (1) metre in length and of a uniform section of one (1) square millimetre at a temperature of twenty (20) degrees Centigrade.

When correcting for temperature, the temperature co-efficient specified by the same Commission will be admitted—that is, at a temperature of twenty (20) degrees Centigrade, the "constant mass" temperature co-efficient of resistance of standard annealed copper is 0.00393 per degree Centigrade.

The diameter of the wires used shall not vary by more than one and a half (1.5) per cent. above or below the nominal diameter.

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* *See* the terminology used in the Addendum to Appendix Bd. 2, No. 1 hereafter.

Factory Joints.—When it is necessary to join conductors in the factory, the joint shall be made by a method which meets the following requirements :—

The tensile strength of a section of a conductor which includes the joint shall be at least ninety (90) per cent. of the tensile strength of an adjacent section of the conductor of equal length without joint.

The resistance of a section of the conductor not exceeding fifteen (15) centimetres (approximately 6 inches) in length, which includes the joint, shall not exceed by more than five (5) per cent. the resistance of an adjacent section of the conductor of equal length without joint. No twist joints shall be used. The material used for the joints must not contain acid. The joints shall be brazed with silver solder.

Insulating Paper.—The paper used for insulating the conductors shall be uniform in texture and thickness, long fibred and free from metallic particles or other deleterious substances.

A sample of paper taken from the finished cable and subjected to exposure to the atmosphere for one hour, shall have a tensile strength of not less than 4 kilometres (approximately 2.5 miles) length of paper of the same dimensions and the same quality.

Sheathing and Armouring Material.—The requirements for these materials shall be specified separately for each individual cable.

Electrical Characteristics.

Conductor Resistance.—The direct current resistance of any wire in a finished manufacturing length shall not exceed by more than four (4) per cent. the value calculated for a straight wire of the nominal size of the conductor considered.

The average resistance of all the wires in a group of one gauge shall not exceed the nominal value, as defined above, by more than one (1) per cent.

For the maximum and for the average value an additional allowance, for the increase in length due to the stranding, shall be made in accordance with the table below :—

Over-all diameter of outer layer containing the gauge considered (in millimetres).	Allowance for the increase in length due to stranding.
Below 30	1·0 per cent.
30–40	1·6 ,,
40–50	2·5 ,,
50–60	3·7 ,,
60–70	5·0 ,,
70–80	7·0 ,,

In any length of cable the difference between the direct current resistances of the two conductors of a pair shall not exceed one (1) per cent. of the loop resistance of that pair.

The difference in direct current resistance between the two pairs of a single quad, the conductors of each pair being taken in parallel in any length of cable, shall not exceed by more than 2 per cent. the loop resistance of the two pairs, the conductors of each pair being taken in parallel.

Insulation Resistance.—In a length of cable each conductor, when measured for insulation against all other conductors and the sheath connected to earth, shall have an insulation resistance equivalent to not less than ten thousand (10 000) megohms per kilometre of cable (approximately 6 200 megohms per mile), the potential difference employed being at least 100 volts and not more than six hundred (600) volts. The reading shall be taken after an electrification of one (1) minute, at a temperature of not less than fifteen (15) degrees Centigrade (approximately 60° F.).

Dielectric Strength.—When specially called for, the cables shall be designed so that the insulation on every length of cable shall be capable of withstanding for two (2) seconds without rupture a fifty (50) period alternating current potential of the R.M.S. value specified in each particular case but not exceeding two thousand (2 000) volts, when applied between all conductors of the cable connected together and the cable sheath earthed.

The maximum value of the testing voltage shall not differ by more than ten (10) per cent. from that of a true sine wave of the same R.M.S. value.

Mutual Capacity (Alternating Current).—The mutual capacity of a pair is the capacity measured between the two conductors of the pair when all the other conductors in the cable are connected to the lead sheath.

The mutual capacity of a phantom circuit is the capacity measured between the two pairs of a quad with each of the pairs short-circuited, and all other conductors in the cable connected to the lead sheath.

The test shall be made with alternating current at room temperature. No correction for temperature shall be applied. In case of dispute, the results obtained with an alternating current of 800 p : s (ω=5 000) at not less than fifteen (15) degrees Centigrade (approximately 60° F.) will be taken as final.

In each length of cable the average mutual capacity of all the pairs of each gauge, taken separately, shall be as specified by the Administration concerned; a tolerance of plus or minus five ($\pm$ 5) per cent. on ninety (90) per cent. of all factory lengths, and a tolerance of plus or minus eight ($\pm$ 8) per cent. on one hundred (100) per cent. of all factory lengths shall be allowed.

In each length of cable the average mutual capacity of phantom circuits of each group of one gauge shall not differ by more than plus or minus five ($\pm$5) per cent. from the value which shall be determined by multiplying the average pair-capacity of that group by the factor 1.62.

This factor is valid for cables with phantom groups. In quad pair cables this factor is smaller; its value should be fixed specially for each particular case.

Note.—*In quad pair cables each phantom circuit is established by means of two diametrically opposed pairs which constitute one of two phantom groups of a double star.*

The mutual capacity of every pair and every phantom circuit shall be measured on not less than ten (10) per cent. of the total number of factory lengths.

In any length of cable the capacity deviation of the pair or phantom circuits, respectively, of a group of one gauge shall not exceed the following values :—Average, 4 per cent.; Maximum, 12½ per cent.

By " capacity deviation " is meant the difference of the capacity of any circuit of a group from the average capacity of all similar circuits of that group in the same factory length. This difference shall be expressed as a percentage of this average value.

Measures to be taken with a view to Equalising, as far as possible, the Capacities of the Loading Sections between Successive Repeaters.

For each group of physical and phantom circuits of the cable the average capacities of the various loading sections between repeater stations should not differ by more than $\pm$ 2 per cent. from the average value of the capacity of the group of circuits in question throughout the whole of the loading sections. Where such regularity could not be obtained directly by manufacturing processes, if there are deviations greater than the limits indicated, it is recommended that the factory lengths be distributed in each loading section in such a manner that the capacities of the various loading sections shall fulfil the condition mentioned above.

Leakance Constant.—The average leakance of the pair and phantom circuits shall be determined on a small percentage of factory lengths with an alternating current of 800 p : s (ω =5 000).

The average leakance constant for each type of circuit for any length tested shall not exceed twenty-five (25). This constant shall be taken as being equal to the ratio of the average leakance and the average mutual capacity measured with alternating current.

This value may also be expressed as the ratio : $G/\omega C$ = Leakance/Susceptance, which must not exceed 0.005.

Capacity Unbalance.—In a cable two hundred and thirty (230) metres (approximately 750 ft.) in length, the capacity unbalances,* measured with alternating current of approximately 800 p : s (5 000 radians per second), shall not exceed the value given in the following table, each gauge being considered separately :—

1. For Commercial Telephone Circuits.

		Limits for capacity unbalance in micro-microfarads per 230 metre lengths.	
		Average.	Maximum.
Between circuits of the same phantom group	Side to Side	40	150
	Phantom to side ...	75	375
	Side to Earth	150	600
	*Phantom to Earth ...	300	1 200
Between circuits in adjacent phantom groups in the same layer or between a phantom group in the first layer and a phantom group in the centre	*Pair to pair	60	225
	*Phantom to pair ...	60	225
	Phantom to phantom ...	60	225

2. Circuits for Relaying Radio-Broadcast Transmission.

		Limits for capacity unbalance in micro-microfarads per 230 metre lengths.
		Maximum.
Screened Circuits.		
(α) Phantom Group	Side to side	150
	Phantom to side ...	375
	Side to earth	600
	*Phantom to earth ...	1 200
(β) Single Pair	Pair to earth	600
Circuits not screened.		
(α) Phantom Group	Side to side of same phantom group	150
	Side to side of adjacent phantom groups ...	225
	Phantom to side ...	375
	Side to earth	600
	*Phantom to earth ...	1 200
(β) Single Pair	Pair to earth	600
	Pair to pair of adjacent phantom groups ...	225
	Pair to phantom of adjacent phantom groups	225

Owing to the large number of measurements that would be involved in making complete tests, it is desirable to limit the measurements marked with an asterisk in the above table to 2 per cent. of the

* *See* page 162 for definitions of capacity unbalances.

factory lengths of an order, with a minimum of two lengths. In exceptional cases the Administrations and Operating Companies concerned may demand a greater number of lengths to be tested. The cable lengths on which these tests are to be made shall be indicated by the Administrations and Operating Companies.

If the capacity unbalances in a cable length exceed the limits specified above, only that length shall be rejected, but the Administration or Operating Company may demand measurements on other cable lengths.

In cables intended for four-wire operation, the average capacity unbalance between circuits in one direction and similar circuits in the other direction shall be measured on one or more factory lengths and the average unbalance for a factory length of 230 metres shall not exceed 3 micro-microfarads.

In each manufacturing length of cable having a length other than 230 metres, the capacity unbalance tested with alternating current for the different conductor diameters, shall not exceed the values obtained when the following rules are applied:—

(*a*) Between the circuits—

Side to side Pair to pair Phantom to pair Phantom to phantom	Average values.

Multiply the values given in the above table, applying to lengths of 230 metres, by the square root of the ratio between the length in question and 230 metres.

(*b*) Between the circuits—

Side to side Pair to pair Phantom to pair Phantom to phantom	Maximum values.
Phantom to side Side to earth Phantom to earth	Average and maximum values.

Multiply the values given in the preceding table by the ratio between the length in question and 230 metres.

This correction shall not apply to lengths of cables less than one hundred (100) metres (approximately 330 feet). For such lengths the limits for a one hundred (100) metre length shall apply, computed in accordance with the preceding rules.

The limits here specified are based on the following definitions for the capacity unbalances.

The capacity unbalance between the side circuits of a quad is the unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one wire of one pair and one wire of the other pair of the quad.

The capacity unbalance between a phantom circuit and either of its side circuits is the capacity unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one wire of a pair and a wire of the other pair.

The capacity unbalance to earth of a side circuit is the difference between the direct capacities of the two wires of the pair to the conductors of all other quads in the cable connected together and to the sheath, which shall be earthed.

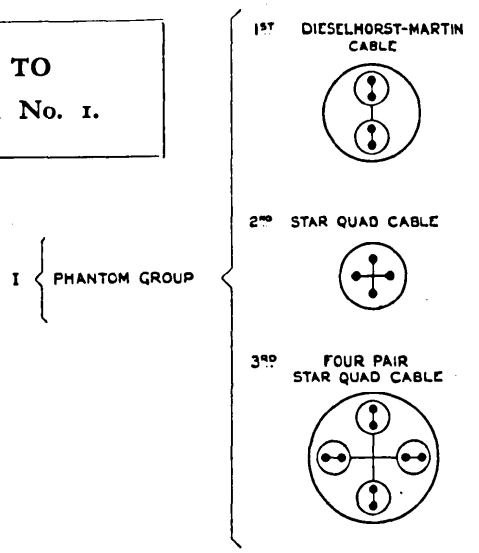
The capacity unbalance to earth of a phantom circuit is the difference between the direct capacities of the two pairs of the quad to the other quads of the cable connected together and to the sheath, which shall be earthed.

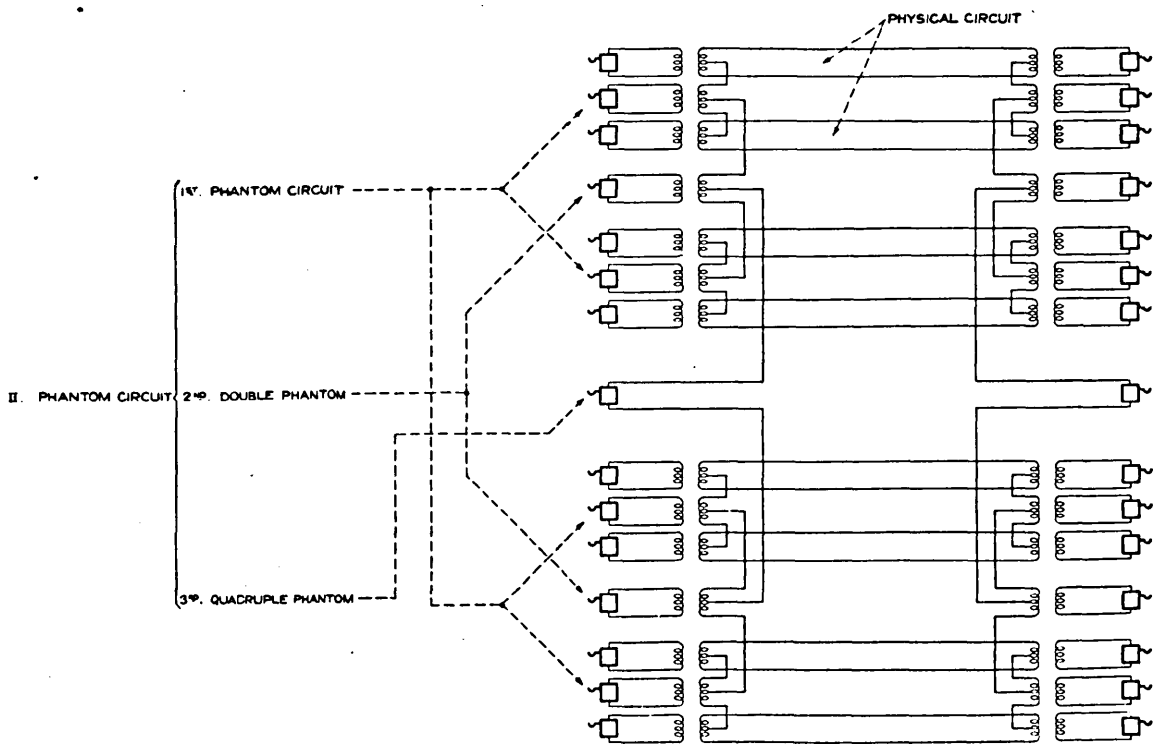
The capacity unbalance between two pairs of different quads is the unbalance which would be produced or corrected, as the case may be, by the introduction of a capacity between one of the wires of one pair and one of the wires of the other pair.

The capacity unbalance between a phantom circuit and either of the two pairs of another quad is the unbalance which would be produced or corrected, as the case may be, by the introduction of a capacity between one of the pairs of the phantom circuit and one of the wires of the pair in question.

The capacity unbalance between two phantom circuits is the unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one of the pairs of one quad and one of the pairs of the other quad.

ADDENDUM TO
APPENDIX B.d.2, No. 1.





APPENDIX B.d.2, No. 2.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION GENERALLY APPLYING TO FACTORY LENGTHS OF INTERNATIONAL TELEPHONE CABLES NOT INTENDED FOR PHANTOM WORKING.

General.—This specification covers the electrical requirements which must be fulfilled by factory lengths of air space, paper-insulated, lead-covered cables for long-distance telephone circuits where phantom circuits are not required. These requirements are specified in order to ensure that the cables will be suitable for :—

1. The loading of physical (pair) circuits.
2. Efficient long-distance working in conjunction with repeaters.

These requirements do not apply :—

1. To cables in which the conductors are smaller than eight-tenths (0·8) of a millimetre (approximately 16 lb. per mile).
2. To groups of one gauge of conductors of less than 20 pairs.
3. When the total number of circuits of each gauge specified is such that the lay-up of the cable is necessarily unsymmetrical, or such that conductors of different gauges are required to be in the same layer.

Some of the more important raw material requirements are also specified.

Raw Materials.

Copper Conductors.—Each conductor shall consist of a wire of pure annealed copper, smoothly drawn, cylindrical, uniform in quality and resistance, free from scales or other defects and having a conductivity equal to that specified by the International Electro-technical Commission (Berlin, 1913); that is, one fifty-eighth ($\frac{1}{58}$) of an ohm for the resistance of a wire of standard annealed copper one (1) metre in length and of a uniform section of one (1) square millimetre at a temperature of twenty (20) degrees Centigrade.

When correcting for temperature, the temperature co-efficient specified by the same Commission will be admitted; that is, at a temperature of twenty (20) degrees Centigrade, the "constant mass" temperature co-efficient of resistance of standard annealed copper is 0.00393 per degree Centigrade.

The diameter of the wires used shall not vary by more than one and a half (1.5) per cent. above or below the nominal diameter.

Factory Joints.—When it is necessary to join conductors in the factory, the joint shall be made by a method which meets the following requirements :—

The tensile strength of a section of a conductor which includes the joint shall be at least ninety (90) per cent. of the tensile strength of an adjacent section of the conductor of equal length without joint.

The resistance of a section of the conductor not exceeding fifteen (15) centimetres (approximately 6 inches) in length, which includes the joint, shall not exceed by more than five (5) per cent. the resistance of an adjacent section of the conductor of equal length without joint. No twist joints shall be used. The material used for the joints must not contain acid. The joints shall be brazed with silver solder.

Insulating Paper.—The paper used for insulating the conductors shall be uniform in texture and thickness, long fibred and free from metallic particles or other deleterious substances.

A sample of paper, taken from the finished cable and subjected to exposure to the atmosphere for one hour, shall have a tensile strength of not less than 4 kilometres (approximately 2.5 miles) length of paper of the same dimensions and the same quality.

Sheathing and Armouring Material.—The requirements for these materials shall be specified separately for each individual cable.

Electrical Characteristics.

Conductor Resistances.—The direct current resistance of any wire in a finished manufacturing length shall not exceed by more than four (4) per cent. the value calculated for a straight wire of the nominal size of the conductor considered.

The average resistance of all the wires in a group of one gauge shall not exceed the nominal value, as defined above, by more than one (1) per cent.

For the maximum and for the average value an additional allowance, for the increase in length due to the stranding, shall be made in accordance with the table below:—

Over-all diameter of outer layer containing the gauge considered (in millimetres).	Allowance for the increase in length due to stranding.
Below 30	1·0 per cent.
30–40	1·6 ,,
40–50	2·5 ,,
50–60	3·7 ,,
60–70	5·0 ,,
70–80	7·0 ,,

Insulation Resistance.—In a length of cable each conductor, when measured for insulation against all other conductors and the sheath connected to earth, shall have an insulation resistance equivalent to not less than ten thousand (10 000) megohms per kilometre of cable (approximately 6 200 megohms per mile), the potential difference employed being at least 100 volts and not more than six hundred (600) volts. The reading shall be taken after an electrification of one (1) minute, at a temperature of not less than fifteen (15) degrees Centigrade (approximately 60° F.).

Dielectric Strength.—When specially called for, the cable shall be designed so that the insulation on every length of cable shall be capable of withstanding for two (2) seconds without rupture a fifty (50) period alternating current potential of the R.M.S. value specified in each particular case, but not exceeding two thousand (2 000) volts, when applied between all conductors of the cable connected together and the cable sheath earthed.

The maximum value of the testing voltage shall not differ by more than ten (10) per cent. from that of a true sine wave of the same R.M.S. value.

Mutual Capacity (Alternating Current).—The mutual capacity of a pair is the capacity measured between the two conductors of the pair when all the other conductors in the cable are connected to the lead sheath.

The test shall be made with alternating current at room temperature. No correction for temperature shall be applied. In case of dispute, the results obtained with an alternating current of 800 p : s at not less than fifteen (15) degrees Centigrade (approximately 60° F.) will be taken as final.

In each length of cable the average mutual capacity of all the pairs of each gauge taken separately shall be as specified by the Administration concerned; a tolerance of plus or minus five (± 5) per cent. on ninety (90) per cent. of all factory lengths, and a tolerance of plus or minus eight (± 8) per cent. on one hundred (100) per cent. of all factory lengths shall be allowed.

The mutual capacity of every pair shall be measured on not less than ten (10) per cent. of the total number of factory lengths.

In any length of cable the capacity deviation of the pair circuits of a group of one gauge shall not exceed the following values: Average, 4 per cent.; Maximum, 12·5 per cent.

By "capacity deviation" is meant the difference of the capacity of any circuit of a group from the average capacity of all similar circuits of that group in the same factory length. This difference shall be expressed as a percentage of the average value.

Measures to be taken with a view to Equalising, as far as possible, the Capacities of the Loading Sections between Successive Repeaters.

For each group of pairs of the cable the average capacities of the various loading sections between repeater stations should not differ by more than ± 2 per cent. from the average value of the capacity of the group of circuits in question throughout the whole of the loading sections. Where such regularity was not obtained directly by manufacturing processes, if there are deviations greater than the limits indicated, it is recommended that the factory lengths be distributed in each loading section in such a manner that the capacities of the various loading sections shall fulfil the condition mentioned above.

Leakance Constant.—The average leakance of the pair circuits shall be determined on a small percentage of factory lengths with an alternating current of 800 p : s ($\omega = 5\,000$).

The average leakance constant for all circuits of one gauge for any length tested shall not exceed twenty-five (25). This constant shall be measured with alternating current.

This value may also be expressed as the ratio: $G/\omega C$ = Leakance/Susceptance, which must not exceed 0.005.

Capacity Unbalance.—In a cable two hundred and thirty (230) metres (approximately 750 ft.) in length, the capacity unbalances measured with alternating current of approximately 800 p : s (5 000 radians per second) shall not exceed the values given in the following table, each gauge being considered separately:—

		Limits for Capacity Unbalance in micro-microfarads per 230 metre length.	
		Average.	Maximum.
Between circuits in the same quad	Pair to pair	40	150
	Pair to earth	150	600
Between circuits in adjacent quads in the same layer or between a quad in the first layer and a centre quad	*Pair to pair	60	225

These unbalance tests require a large number of readings, which it is desirable to reduce. This can most advantageously be done by making tests for the unbalance, marked in the table by an asterisk, on 2 per cent. of the factory lengths of an order with a minimum of two lengths. In exceptional cases Administrations may insist on a larger number of tests being made; factory lengths, on which such additional tests are to be made, should be indicated by the Administrations.

If the capacity unbalances in a cable length exceed the limits specified above, only that length shall be rejected, but the Administration or Operating Company may demand measurements on other cable lengths.

In cables intended for 4-wire operation the average capacity unbalance between circuits in one direction and similar circuits in the other direction shall be measured on one or more factory lengths, and the average unbalance for a factory length of 230 metres shall not exceed 3 micro-microfarads.

In each manufacturing length of cable having a length other than 230 metres, the capacity unbalance tested with alternating current for the different conductor diameters, shall not exceed the values obtained when the following rules are applied :—

(*a*) Between the circuits :—

Side to side Pair to pair	}	Average values.

Multiply the values given in the above table, applying to lengths of 230 metres, by the square root of the ratio between the length in question and 230 metres.

(*b*) Between the circuits :—

Side to side Pair to pair	}	Maximum values.
Side to earth		Average and maximum values.

Multiply the values given in the above table by the ratio between the length in question and 230 metres.

This correction shall not apply to lengths of cable less than one hundred (100) metres (approximately 330 feet). For such lengths the limits for a one hundred (100) metre length shall apply, computed in accordance with the preceding rule.

The limits specified above are based on the following definitions for capacity unbalances.

The capacity unbalance between pairs is the unbalance which would be produced, or corrected, as the case may be, by the insertion of a capacity between one wire of a pair and one wire of the other pair.

The capacity unbalance to earth of a pair is the difference between the direct capacities of the two wires of the pair to the conductors of all other pairs in the cable connected together and to the sheath, which shall be earthed.

The capacity unbalance between two pairs in different quads is the unbalance which would be produced or corrected, as the case may be, by the insertion of a capacity between one of the wires of one pair and one of the wires of the other pair.

APPENDIX B.d.2, No. 3.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR REPEATER SECTIONS OF LOADED INTERNATIONAL TELEPHONE CABLE.

General.—This specification covers the chief electrical requirements of installed repeater section lengths of loaded cable, where the factory lengths of cable and the loading coils are in accordance with their corresponding specifications.

The clauses of this specification are drawn up so as to ensure that the cable shall be suitable for phantom working and for efficient long-distance performance in conjunction with two-wire or four-wire repeaters.

The clauses below apply equally well to two-wire or four-wire circuits, except when otherwise indicated in the text.

Resistance Unbalance.—In any cable section between telephone repeaters, the difference between the direct current resistance of the two conductors of any pair shall not exceed six (6) ohms for conductors of 1 mm maximum diameter, or four (4) ohms for conductors larger than this.

The resistance unbalance of the two pairs of any quad, the conductors of each pair being in parallel, must not exceed 4 ohms for conductors up to 1 mm in diameter or 3 ohms for conductors exceeding 1 mm in diameter.

Insulation Resistance.—The insulation resistance between any wire and all other wires together with the sheath connected to earth, measured from the terminals of the cable, and not including the internal office wiring, shall not be less than five thousand (5 000) megohms per kilometre of cable, this insulation resistance being measured with a difference of potential of at least 100 volts and not more than 600 volts, the readings to be taken after one minute's electrification.

Impedance Balance.—The balance between the impedance Z_{ct} of any side or phantom circuit and the corresponding network impedance Z_{eq}, calculated from the measured average constants of the circuit, shall satisfy the following requirements: after determination, by direct measurement, of the real and imaginary components of the impedance Z_{ct} and Z_{eq}, the difference between the real components and the difference of the imaginary components, will be expressed in percentages, d_e and d_i, of the impedance Z_{eq} of the balancing network, and if d_e and d_i are taken as the Cartesian co-ordinates of a point, this point should be situated within a circle having a radius of $\frac{1\text{A}}{100}$ for all the circuits and for any frequency between 300 and 2 200 periods per second. Further, for 90 per cent. of the circuits and for all the frequencies indicated above, the corresponding point should fall within a circle having a radius of $\frac{1\text{A}}{100}$.

Crosstalk.—The following tables state the maximum crosstalk allowable between any circuits as specified above and measured on any repeater section of cable between two successive repeaters. The values are those which would be measured from the terminals of the cable, and include only crosstalk contributed by the cable and loading coils. They do not include crosstalk introduced by arrestors, terminal transformers, repeater station cabling and other equipment located in the repeater or terminal buildings.

The crosstalk values shall be determined by means of a talking test, or by using the method prescribed by the C.C.I.

The measuring circuits employed shall be such that both the disturbing and disturbed circuits are closed at both ends through impedances which conform to the impedance of the disturbing and disturbed circuits respectively.

The limiting value of attenuation corresponding to the crosstalk expressed in units of transmission shall be at least equal to the values quoted below:—

Near End and Far End Crosstalk, Two-wire Circuits.

Side to side of same quad Phantom to side of same quad Phantom to phantom Phantom to pair of different quads Pair to pair of different quads	8 népers or 69·5 decibels.

Near End Crosstalk, Four-wire Circuits between Opposite-going Four-wire Groups.

Pair to pair Phantom to pair Phantom to phantom	9 népers or 78 decibels.

Far End Crosstalk, Four-wire Circuits between Circuits Transmitting in the same Direction.

Side to side Phantom to side of same quad Phantom to phantom Phantom to pair of different quads Pair to pair of different quads	8·5 népers or 74 decibels.

Note.—The near end and far end crosstalk between any circuit and a circuit used for the relaying of broadcast transmission (including the phantom circuit of the centre quad of a cable loaded in accordance with System Ib) or between the two circuits used for the relaying of broadcast transmission, shall be at least equal to 12 népers (104 decibels).

System of Loading and Cut-off Frequency.—By way of example, two systems are described below under the titles: **System No. I.** and **System No. II.**, the former comprising two alternatives **Nos. Ia** and **Ib.** Both systems are equally satisfactory from an international point of view.

System No. Ia.

(i) **Loading Coil Spacing.**—In any cable section between successive telephone repeaters the average loading coil spacing shall be eighteen hundred and thirty (1830) metres within limits of plus or minus two (± 2) per cent.

The actual length of any loading section, measured along any cable section between two successive repeaters, may vary as a maximum, plus or minus ten (± 10) metres from the normal spacing.

The mean mutual capacity is 0.0385 microfarad per kilometre for side circuits and 0.0625 microfarad per kilometre for phantom circuits.

(ii) **Loading Coil Inductances.**—The loading units used shall have a nominal inductance of one hundred and seventy-seven (177) millihenrys for the side circuits and sixty-three (63) millihenrys for the phantom circuits. This type of loading is known as medium-heavy (mi-forte; mittelstark); alternatively, one hundred and seven (107) millihenrys may be used for the phantom circuits.

For long circuits, not equipped with phase compensators, the loading units should have an inductance of forty-four (44) millihenrys for the side and twenty-five (25) millihenrys for the phantom circuits. This type of loading is known as extra light (légère; leicht).

For a screened pair used for the relaying of broadcast transmission the loading coils will have a nominal inductance of fifteen (15) millihenrys. For a screened quad, of which the phantom is used for the relaying of broadcast transmission, the loading units will have an inductance of one hundred and seventy-seven (177) millihenrys for the side circuits, and of nine (9) millihenrys for the phantom circuit.

(iii) **Cut-off Frequency.**—The cut-off point for the various systems of loading for both side and phantom circuits shall be calculated by the formula :—$\omega_s = 2/\sqrt{LC}$ where ω_s = cut-off point, expressed in radians per second. L = inductance per coil, in henrys. C = mutual capacity of the circuit between loading coils, in farads.

The cut-off point has approximately the nominal values given in the following table :—

	Side.		Phantom.	
	Radians.	Periods per Second.	Radians.	Periods per Second.
Circuits less than 700 km in length.				
With 177 mH side, 63 mH phantom	18 000	2 900	23 600	3 600
With 177 mH side, 107 mH phantom...	18 000	2 900	18 000	2 900
Circuits over 700 km in length.				
With 44 mH side, 25 mH phantom	36 000	5 800	37 400	6 000
With 15 mH side	62 000	9 800	—	—
With 177 mH side, 9 mH phantom	18 000	2 900	63 000	10 000

(iv) **Impedance.**—The characteristic impedance of side and phantom circuits loaded in accordance with the foregoing systems of loading, is calculated from the formula :—

$$Z_0 = \sqrt{L/C}$$

where Z_o = the characteristic impedance (L and C being the constants referred to in paragraph on "Cut-off Frequency") and has the values given in the following table:—

	Ohms Impedance.	
	Side.	Phantom.
Circuits less than 700 km in length.		
With 177 mH side, 63 mH phantom	1 590	740
With 177 mH side, 107 mH phantom	1 590	970
Circuits over 700 km in length.		
With 44 mH side, 25 mH phantom	790	470
With 15 mH side	460	—
With 177 mH side, 9 mH phantom	1 590	280

(v) **Attenuation Constant.**—The average attenuation constant for all circuits of one type, in any section between successive repeaters, loaded in accordance with the foregoing rules of loading, shall not exceed the values quoted in the following tables.

The attenuation constants shall be measured on the cable sections between telephone repeaters, including exact half value terminating loading sections. In cases where exact half value terminating loading sections do not exist, these terminating sections shall be built out to half value by artificial cable, and suitable corrections made to the measurements taken.

The following table gives the values of the attenuation constants for circuits loaded with 177 mH side circuit coils and 63 mH phantom circuit coils on 1 830 m nominal spacing:—

Maximum Average Attenuation per km.

Diameter of Conductors.	At 800 Periods per Second.		At 1 900 Periods per Second.	
	Side Circuit.	Phantom Circuit.	Side Circuit.	Phantom Circuit.
	β	β	β	β
0·9 mm	0·0217	0·0228	0·0250	0·0245
1·3 mm	0·0121	0·0125	0·0164	0·0147

The following table gives the values of the attenuation constants for circuits loaded with 177 mH side circuit coils and 107 mH phantom circuit coils at 1 830 m spacing:—

Maximum Average Attenuation per km.

Diameter of Conductors.	At 800 Periods per Second.		At 1 900 Periods per Second.	
	Side Circuit.	Phantom Circuit.	Side Circuit.	Phantom Circuit.
	β	β	β	β
0·9 mm	0·0214	0·0177	0·0251	0·0202
1·3 mm	0·0119	0·0099	0·0159	0·0127

The following table gives the values of the attenuation for circuits loaded with 44 mH side circuit coils and 25 mH phantom circuit coils on 1830 m spacing.

Maximum Average Attenuation per km.

Diameter of Conductors.	At 800 Periods per Second.		At 1 900 Periods per Second.	
	Side Circuit.	Phantom Circuit.	Side Circuit.	Phantom Circuit.
	β	β	β	β
0·9 mm	0·0390	0·0328	0·0410	0·0339
1·3 mm	0·0197	0·0166	0·0206	0·0174

The following table gives the values of the attenuation of circuits for broadcast transmissions :—

Maximum Attenuation per km.

Diameter of Conductors.	At 800 Periods per Second.	At 1 900 Periods per Second.	At 5 000 Periods per Second.
	β	β	β
1·3 mm (15 mH) side	0·0290	0·0310	0·0320
0·9 mm (177·9 mH) phantom	0·0465	0·0500	0·0540

System No. Ib.

(vi) **Loading Coil Spacing.**—For cables with wires 0.9 mm diameter (having a mean mutual capacity of 0.0335 microfarad per kilometre for the side circuit and 0.054 microfarad per kilometre for the phantom circuit) and for those with wires 1.4 mm diameter (having a mutual capacity of 0.0355 microfarad per kilometre for the side circuit and 0.057 for the phantom circuit) the nominal loading coil spacing shall be two thousand (2 000) metres $\pm$ 2 per cent.

In any cable section between two successive telephone repeaters the actual length of any loading section (measured along the cable) shall not vary from the nominal spacing by more than plus or minus ten ($\pm$ 10) metres.

(vii) **Loading Coil Inductances.**—The loading units for circuits not exceeding 700 km in length shall have a nominal inductance of two hundred (200) millihenrys for the side circuits and seventy (70) millihenrys for the phantom circuits, when 0.9 mm conductors are used; and one hundred and ninety (190) millihenrys for the side circuits and seventy (70) millihenrys for the phantom circuits, when 1.4 mm conductors are used. The limit of seven hundred (700) km may be extended to one thousand (1 000) km for 4-wire circuits if this extension does not produce disturbing echo currents.

For long circuits not equipped with phase compensators, the loading units shall have a nominal inductance of fifty (50) millihenrys for the side circuits and twenty (20) millihenrys for the phantom circuits.

For the central screened quad, the phantom circuit of which is used for broadcast relays, the inductance of the loading coils inserted in the side circuits is 200 millihenrys and the total inductance of the phantom circuit is 9.4 mH.

(viii) **Cut-off Frequency.**—The cut-off points, calculated by the previously mentioned formula, will have the approximate values given in the following table :—

	Side.		Phantom.	
	Radians.	Periods.	Radians.	Periods.
Circuits less than 700 km in length.				
Wires of 0·9 diameter (200 mH side, 70 mH phantom)	17 300	2 750	23 000	3 670
Wires of 1·4 mm diameter (190 mH side, 70 mH phantom)	17 200	2 740	22 100	3 520
Circuits over 700 km in length.				
Wires of 0·9 mm diameter (50 mH side, 20 mH phantom)	33 500	5 340	43 000	6 840
Wires of 0·9 mm diameter (200 mH side, 9·4 mH phantom)	17 300	2 750	62 800	10 000

(ix) **Impedance.**—Calculated by the previously mentioned formula, the characteristic impedance shall have the values given in the following table :—

	Ohms Impedance.	
	Side.	Phantom.
Circuits less than 700 km in length.		
Wires of 0·9 mm diameter (200 mH side, 70 mH phantom)	1 730	805
Wires 1·4 mm diameter (190 mH side, 70 mH phantom)	1 630	775
Circuits over 700 km in length.		
Wires of 0·9 mm diameter (50 mH side, 20 mH phantom)	855	440
Wires of 0·9 mm diameter (200 mH side, 9·4 mH phantom)	1 730	307

(x) **Attenuation.**—The table below gives the values of the attenuation for circuits of :—

1. 0·9 mm diameter (loaded with 200 mH side circuit coils and 70 mH phantom circuit coils, with 2 000 metre spacing, and mean mutual capacities of cable :—side circuit 0·0335 microfarad per kilometre, phantom circuit 0·054 microfarad per kilometre).

2. For circuits of 1·4 mm diameter (loaded with 190 mH side circuit coils and 70 mH phantom circuit coils, with 2 000 metre spacing, with a mean mutual capacity of cable:—side circuit 0·0355 microfarad per kilometre, phantom circuit 0·0585 microfarad per kilometre.)

Maximum Average Attenuation per km.

Diameter of Conductors.	At 800 Periods per Second.		At 1 900 Periods per Second.	
	Side Circuit.	Phantom Circuit.	Side Circuit.	Phantom Circuit.
	β	β	β	β
0·9 mm	0·0197	0·0210	0·0236	0·0234
1·4 mm	0·0097	0·0101	0·0133	0·0131

The following table gives the values of the attenuation for circuits of 0.9 mm diameter, loaded with 50 mH coils on the side circuits and 20 mH coils on the phantom circuits, the normal spacing being 2 000 metres and the mean mutual capacity 0.0335 μF per km side circuit, and 0.054 μF per km phantom circuit.

Maximum Average Attenuation per km.

Diameter of Conductor.	At 800 Periods per Second.		At 1 900 Periods per Second.	
	Side Circuit.	Phantom Circuit.	Side Circuit.	Phantom Circuit.
	β	β	β	β
0·9	0·0307	0·0350	0·0308	0·0353

The following table gives the values of the attenuation for phantom circuits of the central screened quad, loaded with 9.4 mH coils (loading spacing : 2 000 m) and having a capacity of 0.054 μF per km, the side circuits being loaded with 200 mH coils.

Maximum Average Attenuation per km.

Diameter of Conductor.	At 800 Periods per Second.	At 1 900 Periods per Second.	At 5 000 Periods per Second.
	β	β	β
0·9 mm (phantom screened)	0·042	0·046	0·050

System No. II.

(xi) **Loading Coil Spacing.**—For cables consisting of wires of 0.9 mm diameter (and having an average mutual capacity of 0.0335 microfarad per kilometre for side circuits and 0.054 microfarad per kilometre for phantom circuits) and for cables consisting of wires of 1.4 mm diameter (having a mutual capacity of 0.0355 microfarad per kilometre for side circuits and 0.057 microfarad for phantom circuits) the nominal loading coil spacing shall be seventeen hundred (1 700) metres (within ± 2 per cent).

In a repeater section of cable, the actual loading coil spacing (measured along the length of the cable) must not vary from the nominal loading coil spacing by more than plus or minus ten (± 10) metres.

(xii) **Loading Coil Inductances.**—The loading units employed on side circuits shall have a nominal inductance of 140 millihenrys, and those employed on phantom circuits of 56 millihenrys.

The loading units used on very long circuits, for special reasons designed to transmit a very broad frequency band, shall have a nominal inductance of 30 millihenrys for the side circuits and 12 millihenrys for the phantom circuits.

(xiii) **Cut-off Frequency.**—The values of the cut-off frequency calculated from the formula $\omega_s = \frac{2}{\sqrt{LC}}$ are given, approximately, in the following table :—

	Side.		Phantom.	
	Radians.	Periods per Second.	Radians.	Periods per Second.
Conductor diameter 0·9 mm (140 mH side, 56 mH phantom)	22 500	3 500	28 000	4 400
Conductor diameter 1·4 mm (140 mH side, 56 mH phantom)	21 700	3 400	27 000	4 300
Conductor diameter 1.4 mm (30 mH side, 12 mH phantom)	45 500	7 250	56 500	9 000
Conductor diameter 0·9 mm (30 mH side, 12 mH phantom)	48 400	7 700	58 400	9 300
Conductor diameter 1·4 mm (12 mH side), metallically screened for broadcast transmissions ...	70 000	11 000	—	—

(xiv) **Impedance.**—The characteristic impedance, calculated from the formula $Z_0 = \sqrt{LC}$ shall have the values given in the following table :—

	Ohms Impedance.	
	Side.	Phantom
Conductor diameter 0·9 mm (140 mH side and 56 mH phantom)	1570	780
Conductor diameter 1·4 mm (140 mH side, and 56 mH phantom)	1520	760
Conductor diameter 1·4 mm (30 mH side, and 12 mH phantom)	710	360
Conductor diameter 0·9 mm (30 mH side, and 12 mH phantom) metallically screened for broadcast transmissions	730	370
Conductor diameter 1·4 mm (12 mH side) metallically screened for broadcast transmissions ...	460	—

(xv) **Attenuation.**—The following table gives the attenuation values for :—

1. A circuit having a diameter of 0.9 mm loaded with coils of 140 millihenrys for the side circuit and 56 mH for the phantom circuit, spaced at a distance of 1 700 metres, and having an average mutual capacity of 0.0335 microfarad per kilometre for the side circuit and 0.054 microfarad per kilometre for the phantom circuits;

2. A circuit having a diameter of 1.4 mm loaded with coils of 140 millihenrys or 30 millihenrys for the side circuit and 56 millihenrys or 12 millihenrys for the phantom circuit, spaced at a distance of 1 700 metres, and having an average mutual capacity of 0.0355 microfarad per kilometre for the side circuit and 0.0585 microfarad per kilometre for the phantom circuit.

Maximum Average Attenuation per km.

Diameter of Conductors.	At 800 Periods per Second.		At 2200 Periods per Second.	
	Side.	Phantom.	Side.	Phantom.
	β	β	β	β
0·9 mm (140/56 mH)	0·0195	0·0190	0·0225	0·0205
1·4 mm (140/56 mH)	0·0095	0·0095	0·0125	0·0115
1·4 mm (30/12 mH)	0·0166	0·0164	0·0172	0·0168
0·9 mm (30/12 mH)	0·0390	0·0385	0·0410	0·0410
1·4 mm (12 mH)	0·0244	—	0·0260	—

(xvi) **Phase Compensation.**—Circuits likely to be used for long-distance international communication should be supplied with phase compensators.

APPENDIX B.d.2, No. 3a.

GUIDING PRINCIPLES FOR SETTING UP ESSENTIAL CLAUSES OF A SPECIFICATION FOR THE SUPPLY OF SUBMARINE TELEPHONE CABLES (TO THE EXCLUSION OF INTERCONTINENTAL CABLES OF VERY LONG LENGTH).

A. General Conditions.

1. **General.**—In general, submarine telephone cables must satisfy the same conditions concerning quality of transmission as land cables. However, considering that submarine cables are better protected against disturbing noises (this allows the use of a smaller level at the receiving end and an attenuation in the cable greater than the attenuation in a land cable, which gives appreciable economic advantages), it is advisable to determine for submarine cables permissible levels which are different from those specified for land cables.

2. **Level at the Receiving End.**—The minimum value of this level depends upon the importance of disturbing noises in the cable. In accordance with the conditions for land cables for a level of relative power to — 1.0 néper, half the noise E.M.F. must be at the most equal to 2.5 mV. Consequently, for relative zero level half the maximum noise E.M.F. permissible is equal to $2.5 \times e^1 = 6.8$ mV. The absolute level of half the noise E.M.F. must therefore be at the most

$$\log_e \frac{6.8}{775} = -4.8 \text{ népers of the relative zero level.}$$

If it is considered that this maximum permissible level is still sufficient in the case of submarine cables, it is possible to deduce the permissible relative level at the receiving end from the value of half the noise E.M.F. actually stated. In the following table the relation between half the noise E.M.F., U_g, and the minimum relative level allowed P_m, is shown

U_g	0·001	0·005	0·01	0·05	0·1	0·5	1·0	2·5	mV
$P_{min.}$	−8·8	−7·2	−6·5	−4·9	−4·2	−2·6	−1·9	−1·0	népers

In accordance with present day experience, half the noise E.M.F. on submarine cables is less than 0.01 mV; when these cables are not directly connected to land cables, this is in general of the order of 0.001 mV. When land cables are directly connected to submarine cables, the relative level at the receiving end is limited by the value of the noise voltage in the land cables. For this reason it is always advantageous to place repeaters as near as possible to the shore between the submarine cable and the land cable.

3. **Relative level at the sending end of the submarine cable.**—This level depends above all on the characteristics of nonlinear distortion of the substance used for loading the cable. If the submarine cable forms part of a long telephone line the maximum value of the extra attenuation due to hysteresis for the whole of the line must be the same as for long international telephone circuits. This value has been suggested at 0.1 néper at 800 cycles, the power being 1 mW at zero level. This maximum value can only be allowed for a submarine cable if it is connected to a land cable of short length. Generally, it will be advisable to fix 0.05 néper as the maximum value of extra attenuation due to hysteresis for a submarine cable alone.

By extra attenuation due to hysteresis for an absolute level at the sending end of the cable equal to $+p$ népers, must be understood the difference between the attenuation due to the cable when it transmits a power whose value at the output is equal to e^{2p} mW and its attenuation when it transmits practically no power.

4. **Attenuation of the cable, stability, crosstalk.**—The permissible attenuation is given by the difference between the level at the sending end and the level at the receiving end of the cable; it is, on the other hand, limited by the value of stability and crosstalk attenuation that can be obtained. The crosstalk attenuation, measured with voice, must be more than 6.5 népers at least below the attenuation of the cable so that, with an equivalent of 1 néper, the crosstalk attenuation (near end or far end) should be effectively 7.5 népers at a minimum.

In the case of phantom submarine cables, it is sometimes difficult to maintain the low limit fixed above for crosstalk attenuation; although it may be desirable never to go below this limit, as an exception the crosstalk attenuation on circuits of this type, may be allowed to be a little less than the fixed limit, because of the difficulty stated.

Factory lengths of the cable, in particular cables with 2-wire circuits, must have as far as possible a uniform construction; and it will be desirable not to employ any method of equalising which might cause unbalance disturbances when submarine cables are repaired.

5. **Miscellaneous conditions.**—The requirements as regards band of frequencies effectively transmitted, variations of the equivalent with frequency and the absence of reflections at the junctions of the cable and repeaters, must be the same as for land cables. The values of the speed of propagation and the transient period (duration of transient phenomena) are in fact different from those with land cables for—as found from long transoceanic cables—the time of propagation on the submarine cable itself is in general not to be considered and because phase compensation can easily be obtained by means of appropriate arrangements. Therefore the cut-off frequency is principally dependent upon economic considerations.

Note.—The present Guiding Principles do not include conductor resistance, resistance unbalance, and insulation resistance. Administration, and Operating Companies will fix these themselves in every particular case.

B. Operating Conditions.

1. **Four-wire Circuits.**—In 4-wire operation it is possible to remedy, to a large extent, the crosstalk between transmission in different directions because of suitable separation. Taking into account all the above conditions, it is possible to allow without hesitation an attenuation of 6 népers for the cable at the maximum frequency of the effective band transmitted.

2. **Two-wire Circuits.**—In 2-wire operation values for attenuation of the cable and balances (between impedance of the line and network) must be obtained to give sufficient stability. If 2-wire circuits in submarine cables are continued on land by 2-wire circuits, the conditions for 2-wire land cables must be fulfilled.

When 2-wire circuits on submarine cables are continued on land by 4-wire circuits, the following must be taken into consideration.

First Case.—Two-wire circuits in submarine cable between two 4-wire circuits (Fig. 1).

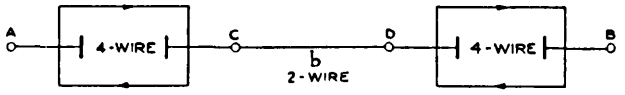


FIG. 1.

Symbols.

Equivalent of the whole connection between A & B	b_r
Attenuation of the submarine cable between C & D	b
Echo attenuation of the terminal at A & B	o
Echo attenuation of the terminal at C & D	b_e
Echo attenuation of the terminal at C & D assuming the submarine cable to be infinitely long	b_0
Stability of the 4-wire circuits AC or BD	b_{pf}
Variation of the impedance of the submarine cable	$\Delta = 2\left\lvert\frac{Z-W}{Z+W}\right\rvert$

Where Z is the calculated characteristic impedance and W the measured characteristic impedance.

For the equivalent between A & B to be equal to b_r each of the 4-wire sections AC and BD must have a gain $s = \frac{b - b_r}{2}$

Under the most unfavourable conditions the stability of the 4-wire circuit, according to the arrangement, is given as

$$b_{pf} = \frac{b_e + o - 2s}{2} = \frac{b_e - b + b_r}{2}$$

(*See* also the remark made below.)

The echo attenuation b_e is calculated from the echo attenuation of the cable of infinite length ($b_0 = \log_e \frac{2}{\Delta}$ this echo attenuation being due to the impedance variation of the cable ... Δ), and from the term for the reflection on the 4-wire circuits; these reflected currents return with an attenuation equal to $2b - 2s = b + b_r$.

Accordingly, when the reflected currents are in the least favourable phase relationship

$$e^{-b_e} = e^{-b_0} + e^{-(b + b_r)}$$

Inserting this in the formula for stability, the value of permissible attenuation of the cable, after making the calculation, becomes

$$b = b_0 - b_r + \log_e (e^{2b_r} - 2^{b_{pf}} - 1)$$

Second Case.—The submarine cable at the extremity of a 4-wire circuit (Fig. 2).

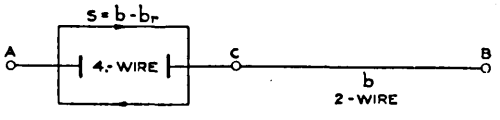


FIG. 2.

Using the same notation as for the first case the permissible attenuation becomes

$$b = \tfrac{1}{2} b_0 + \tfrac{1}{2} \log_e (e^{2b_r} - e^{2b_{pf}} - 1)$$

In the second case, an equivalent a little higher can be allowed, that is to say, of the order 1.0 néper (b_r = 1.0 néper); on Fig 4. is shown the maximum value of the attenuation of the cable.

If a two-wire repeater is inserted at B the second case becomes indentical to the first case, so that in this case a greater attenuation could be allowed.

As shown in the two figures 3 and 4 the maximum permissible attenuation of the submarine cable depends mostly on the uniformity of the impedance of the cable. To-day such progress has been made in the manufacture and maintenance of cables that it is rare to have impedance variation greater than

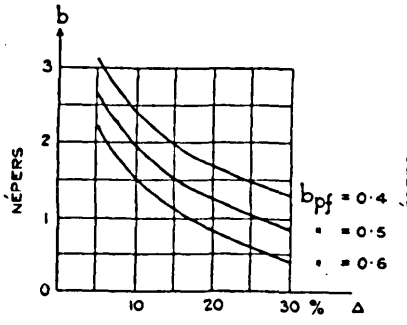


FIG. 3.

Permissible maximum attenuation of submarine cable between two 4-wire circuits (b_r = 0·8).

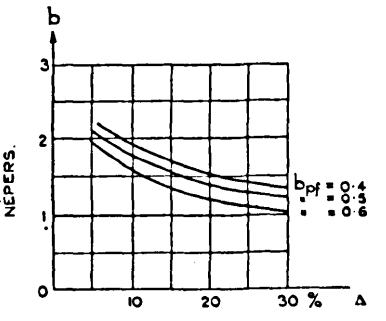


FIG. 4.

Permissible maximum attenuation of submarine cable at the extremity of a 4-wire circuit (b_r = 1·0).

10 per cent. For a stability of 0.5 néper (*) the maximum value of the attenuation of a 2-wire submarine circuit between two 4-wire circuits is given by

$$b = 2.0 \text{ népers}$$

and for the maximum permissible attenuation of a 2-wire submarine cable at the end of a 4-wire circuit

$$b = 1.8 \text{ népers.}$$

3. **Telephone Connections with Carrier Currents.**—In the case of carrier current telephony (for example two frequency band system) the conditions previously indicated must be fulfilled for all paths. As regards attenuation due to hysteresis, it is necessary to take account of the fact that higher frequencies are used on the carrier path.

4. **Use of Phantom Circuits.**—The question of recommending the use of phantom circuits on submarine cables depends upon the possibility of reducing the side to phantom crosstalk in submarine cables which are for the most part star quad cables. The use of phantom circuits is not in general advisable in submarine cable of very high attenuation.

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* In the case of stability where the 4-wire circuit has its end open or short circuited, that is to say, where the termination is nothing or infinity. When the termination has a finite value, the stability is greater than 0·5 néper. The degree of stability depends then upon the impedance of the line of prolongation, but as this impedance has always a finite value (under the condition that this line is stable in itself) it is seen that this case is the most unfavourable.

APPENDIX B.d.2, No. 4.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION FOR THE SUPPLY OF A COMPLETE TELEPHONE CABLE BETWEEN TERMINAL EXCHANGES, INCLUDING REPEATER STATIONS, ASSUMING THAT THE CABLE IS ORDERED FROM ONE CONTRACTOR, WHO ASSUMES RESPONSIBILITY FOR OVER-ALL RESULTS.

The International Consultative Committee recommends that the following information should be given to the contractors in as much detail as possible :—

1. Details of the route.
2. Detailed information as to the number of circuits necessary and the expected traffic.
3. Details of telephone and telegraph cables existing on the projected route, if any.
4. Ducts and manholes available along the route, if any.
5. Detailed information as to repeater stations, if any.
6. Location preferred for new repeater stations and reasons justifying this preference.
7. Power supply available at these points.
8. Initial and final capacities of the new repeater stations.
9. Type of construction preferred; aerial cable, underground cable (armoured or non-armoured).
10. Detailed information as to available poles in the case of aerial cables.
11. Information on the power systems liable to produce inductive disturbances or electrolytic damage.

Specification.

1. **Component Parts of the Circuits.**—The various parts of the circuits should conform with the corresponding specifications published by the C.C.I.

The parts in question and the corresponding specifications are the following :—

Cable	Factory Lengths	Appendices B.d.2, No. 1, and B.d.2, No. 2.
	Cable Terminals	Appendix B.c.3, No. 1.
	Repeater Section	Appendix B.d.2, No. 3.
Loading Coils (Pupin Coils)		Appendix B.d.2, No. 5.
Repeaters		Appendices B.c.4, No. 1, and B.c.4, No. 2.
Signalling Apparatus		Appendix B.c.4, No. 4.
Terminal Apparatus		Appendix B.c.4, No. 7.
Testing and Measuring Apparatus		Appendix B.c.4, No. 8.
Echo Suppressors		Appendix B.c.4, No. 6.
Current Supply Installations		Appendix B.c.4, No. 3.
Balancing Networks for 2-wire Repeaters		Appendix B.c.4, No. 5.
Line Transformers		Appendix B.c.3, No. 3.
Protective Apparatus		Appendix B.c.3, No. 2.

2. **Equivalent and Distortion.**

(*a*) The equivalent of a circuit, measured between test boards at the terminal exchanges, shall not exceed the values specified below. Regarding permissible limits of variation of the equivalent with frequency, the frequency band to be considered as effectively transmitted, these are to be as follows for the various cases :—

At least 300 to 2 000 p : s for medium-heavy loaded 2-wire and 4-wire circuits;
At least 300 to 2 000 p : s for circuits, operating on the high frequency carrier principle;
At least 300 to 2 500 p : s for light-loaded 2-wire and 4-wire circuits.

For all cable circuits which will be placed in the future, the effective frequency band transmitted shall be at least between 300 and 2 400 p : s.

(*b*) The equivalent of a circuit, measured at 800 p : s, should have the same value in both directions with a maximum tolerance of 0·3 néper or 2·5 decibels. For the other frequencies in the effectively transmitted band the tolerances should be greater; in any case, the permissible limits for variation of the equivalent with the frequency indicated below shall not be exceeded.

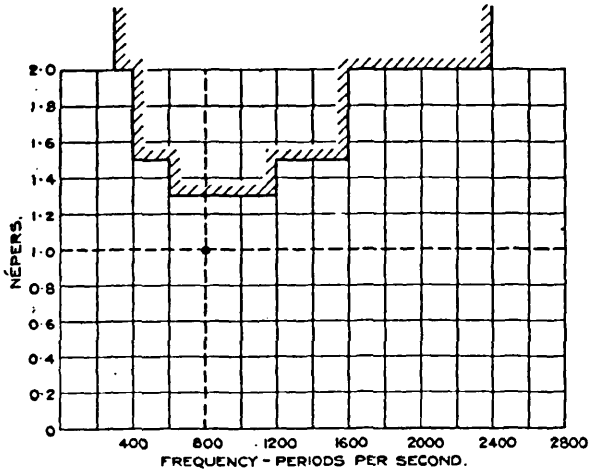
(ε) The permissible limits for the variation of the equivalent with frequency should satisfy the following conditions :—

(α) **Two-Wire Circuit (Graph No. 1).**

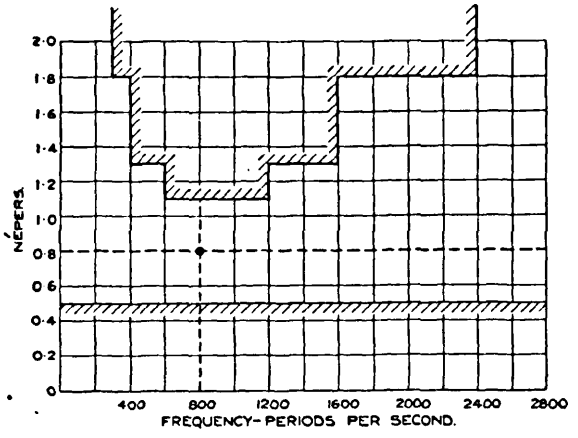
1. In principle the equivalent should not exceed 1·3 népers or 11·3 decibels within the frequency range 600 to 1 200 p : s ; 1·5 népers or 13 decibels for the frequency ranges 400 to 600 and 1 200 to 1 600 p ; s.

2. The equivalent should not exceed 2·0 népers or 17·3 decibels for the other frequencies, considered as effectively transmitted.

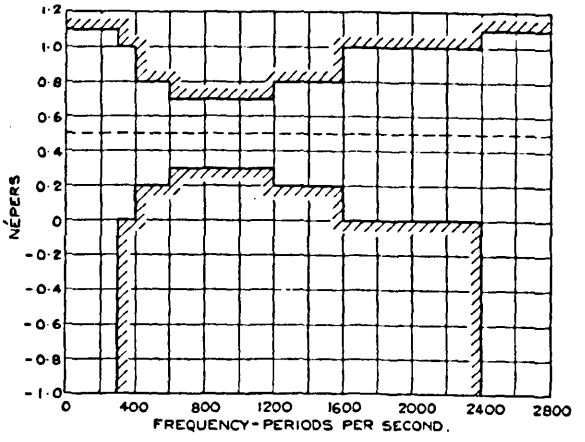
3. The values of the equivalent indicated above are fixed on the assumption that the value of the equivalent measured at 800 p : s is 1·0 néper or 8·7 decibels ; in the case where the 800-cycle equivalent differs from this



GRAPH NO. 1. TWO-WIRE CIRCUITS.



GRAPH NO. 2. FOUR-WIRE CIRCUITS.



GRAPH NO. 3. FOUR-WIRE CIRCUITS.

value, but below 1·3 népers or 11·3 decibels, the figures 1·3 népers or 11·3 decibels, 1·5 népers or 13 decibels, 2·0 népers or 17·3 decibels, should be augmented by the positive or negative difference between the actual value of the equivalent, measured at 800 p : s and the value 1·0 néper or 8·7 decibels.

4. Reducing the over-all transmission loss by 0·4 néper or 3·4 decibels shall not cause singing.

(β) **Four-Wire Circuits (see Graph No. 2).**—A 4-wire circuit must satisfy the following conditions, which are applicable in the case where the circuit does not include the special stabilisation equipment, such as echo suppressors :—

1. The equivalent must never be less in value than 0·5 néper or 4·3 decibels for any frequency whatsoever.

2. In principle the equivalent must not exceed the values: 1·1 népers or 9·5 decibels for frequencies between 600 and 1 200 p : s; 1·3 népers or 11·3 decibels for frequencies between 400 and 600 p : s and also 1 200 and 1 600 p : s.

3. The equivalent must not exceed the value of 1·8 népers or 15·6 decibels for the other frequencies considered to be effectively transmitted.

4. The values of the equivalent (1·1 népers or 9·5 decibels; 1·3 népers or 11·3 decibels; 1·8 népers or 15·6 decibels) given above are assumed on the understanding that the value of the equivalent measured at 800 p : s is 0·8 néper or 6·95 decibels; in the case where the equivalent at 800 p : s differs from this value but lies between the limits 0·5 néper or 4·35 decibels and 1·1 népers or 9·5 decibels; the value 1·1 népers or 9·5 decibels; 1·3 népers or 11·3 decibels; 1·8 népers or 15·6 decibels, must be increased by the positive or negative difference between the real value of the equivalent measured at 800 cycles and by 0·8 néper or 6·95 decibels.

(*d*) The contractor should give detailed information on the methods of obtaining these results, as well as curves showing how the attenuation of the line (repeaters and attenuation equalisers not included) varies with frequency, and also curves showing the variations with frequency, between the limits indicated above, of the over-all attenuation of the circuit (including repeaters and attenuation equalisers).

The contractor should furnish means which guarantee that the variations of the equivalent, due to usual variations in atmospheric conditions, shall not be greater than ± 0.2 néper or 1.7 decibels. For aerial cables, where it is impossible to maintain these limits by manual adjustment, the contractor should consider the use of automatic devices for a permanent control of the gain and furnish all necessary information.

3. **Relative Levels.**—In the following recommendations the origin, for the determination of relative levels, has been taken as the end of the circuit at the sending office (test board at that office).

A correction must be made to take account of the difference in impedance of the line at the two points at which the measurement is carried out. If at the point considered the value of the power voltage or current, as the case may be, is greater than the corresponding value measured at the sending end, the level in this case is positive (+ *n*); if it is less, the sign is negative (− *n*).

The contractor should give detailed information as to the variation in transmission levels for each of the type of circuits contracted for.

In the case of 4-wire circuits, granted that the equivalent may vary with frequency within the limits specified above, it is agreed to adopt the limits given below (Graph No. 3) for this type of circuit and for the power levels at the output terminals of the repeaters in the frontier stations.

The nominal power level is, in principle, fixed at + 0.5 néper or + 4.3 decibels ; in principle :—

From 600 to 1 200 p : s	The variation should not exceed ± 0.2 néper or ± 1.75 decibels.
From 400 to 600 p : s and from 1 200 to 1 600 p : s	The variation should not exceed ± 0.3 néper or ± 2.6 decibels.
From 300 to 400 p : s and from 1 600 to 2 400 p : s	The variation should not exceed ± 0.5 néper or ± 4.3 decibels.

The power level shall not be greater than + 1.1 népers or + 9.55 decibels for any of the frequencies effectively transmitted.

4. **Echo Effects.**—There must be no appreciable echo effects when a conversation is carried out between two terminal exchanges by means of ordinary telephone apparatus, including or not including anti-side tone devices.

In order to satisfy this condition and to eliminate the possible echo effects, special means should be employed where this becomes necessary (echo suppressors).

The contractor must forward detailed information as to the measures taken to ensure the absence of echo on the terminated circuit.

5. **Transient Phenomena.**—On terminating circuits there should not be any appreciable alteration in the articulation (quality of speech) on account of transient phenomena.

A value of 30 milli-seconds is considered as a provisional maximum value for the duration of transients within the frequency band to be transmitted. (*See* the Supplement to Appendix B.d.2, No. 4.)

6. **Stability of Circuits.**—Circuits must remain stable under all ordinary atmospheric conditions and for all the normal conditions of termination for which the circuit has been designed.

From this point of view, the circuit is considered as unstable when the quality of the conversation is appreciably affected by any reaction produced at any point in the circuit, even if this does not consist of actual "singing" (howling).

In order to ensure that a telephone circuit fulfils the conditions indicated above, the amplification of the repeaters on the circuit, assumed to be connected to the usual equipment, should be maintained at a value sufficiently below the singing point.* The stability of a 2-wire circuit shall not be less than 0.4 néper or 3.4 decibels. The stability of a 4-wire circuit shall not be less than 0.5 néper or 4.4 decibels. When the plugs are not inserted in the circuit jacks the circuit shall not sing.

7. **Crosstalk and other Disturbances.**—Crosstalk shall be measured and corrected by the method recommended by the C.C.I. (*See* p. 96.)

Crosstalk measured in the various component parts of the circuits shall remain within the limits fixed in each of the separate foregoing specifications. It is desirable to choose the various component parts of international circuits in such a way as to obtain on these circuits as low a value of crosstalk as possible.†

In commercial working international circuits should be protected from disturbance due to external causes (*e.g.*, power lines) or causes arising in the repeater stations themselves.‡

8. **Crosstalk between Pairs of Four-wire Circuits.**—Measures shall be taken to reduce to a minimum the crosstalk between pairs of conductors used for the "go" and "return" of a 4-wire circuit; for example, the conductors in "go" conductors shall be separated from the "return" conductors throughout the whole length of the cable, as well as in the repeater stations. The contractor should indicate the means adopted in this respect.

Note.—The points mentioned below have not been quoted in the typical specification, the International Consultative Committee considering that in the present state of the art, it is not possible to specify figures. The C.C.I. has merely put on record the following considerations accompanied by authoritative information.

(a) Type of Repeaters, Loading, etc.

The contractor should give detailed information on the gauge of the conductor, the type of loading, the spacing and the type of repeaters which he proposes to instal.

The C.C.I. recommend the following numerical limits. The contractor should explain any appreciable deviation from these limits.

Gauge of Conductors.—The C.C.I. recommends that diameters at least equal to 0.9 mm or 1.3 mm should be adopted for the conductors of underground cables, on the understanding, however, that there will not be more than two types of conductors in the same cable.

Type of Loading.—The type of loading has been specified in the "Essential clauses for a typical specification for a section included between two successive repeaters," but the C.C.I. desires to point

* For the exact definition of the "singing point" refer to page 94 of this book.

† *See* p. 183, paragraph (*b*), headed: "Crosstalk."

‡ Investigation is in progress to determine the maximum tolerable limits of noise due to various disturbances.

out that on very long circuits in which echo effects or transient phenomena become harmful it is necessary to take steps to eliminate or reduce these effects by the insertion of echo suppressors, the application of extra-light loading or the insertion of phase correctors.

Type of Repeaters and Spacing of Repeaters.—The C.C.I. considers that the choice of the type of repeater (2-wire or 4-wire) depends to such an extent on the quality of the lines, etc. . . . that, in view of the numerical limits recommended at present for distortion, transient phenomena and echo effects, there is no need to specify any definite value of attenuation, above which the 2-wire system should be used instead of the 4-wire system, nor to specify the positions of repeater stations.

(b) Crosstalk.

Experiments have been made to fix the maximum tolerable value of crosstalk on long telephone circuits. The value to which these experiments have led corresponds to an attenuation of 6.2 népers or 54 decibels. For this value, speech on one circuit can just be heard on the other circuit, but it becomes quite unintelligible when heard from subscribers' instruments. In any case, it is extremely desirable to obtain a value of crosstalk corresponding to a higher attenuation, and all practicable means should be made to attain this end.

It is considered that on circuits of a length less than 500 km crosstalk should be considerably less than that corresponding to the above value.

Supplement to APPENDIX B.d.2, No. 4.

NOTE BY MESSRS. SIEMENS & HALSKE ON THE LIMITS IMPOSED BY TRANSIENT PHENOMENA ON THE EFFECTIVE CIRCUIT LENGTH AND MEANS FOR INCREASING THE LENGTH OF LOADED CIRCUITS.

1. Considerations of the Disturbing Effects of Transient Phenomena.

Transient phenomena manifest themselves on long loaded telephone cables by whistling sounds mixed with the transmitted speech; moreover, the speech sounds are less accentuated. The latter effect is more harmful from the point of view of articulation. Given that transients represent disturbances whose durations are limited, it follows that their disturbing effect can be reduced by prolonging the speech sounds. In effect, observations show that on long telephone circuits the articulation decreases in proportion as the speech is quicker. For example, a reduction in syllable articulation of only 3 per cent. has been noted on a 1000 km medium-heavy loaded circuit when speaking slowly and clearly, and about 7 per cent. on a 2000 km circuit.

In this case, however, it is practically impossible to receive the conversation correctly when the speech is rapid. It follows then that, although transient disturbance can be compensated for up to a point by speaking slowly, the practical result is that the quality of the service is reduced. Consequently, the utility of telephone circuits is reduced in proportion as the line is lengthened.

2. Physical Origin of Transient Phenomena.

The transient phenomena which are manifested on long loaded telephone circuits are due to the different velocity of propagation of the various wave components in the speech, and consequently they arrive at the end of the circuit relatively displaced in time. The reason for this is the variation of the phase angle a with frequency (ω) between the currents entering and leaving the circuit. No transient distortion is produced only when the phase angle increases in direct proportion to the frequency.

The time of propagation for a wave of frequency ω is given by

$$t = \frac{da}{d\omega} \quad \text{.....(1)}$$

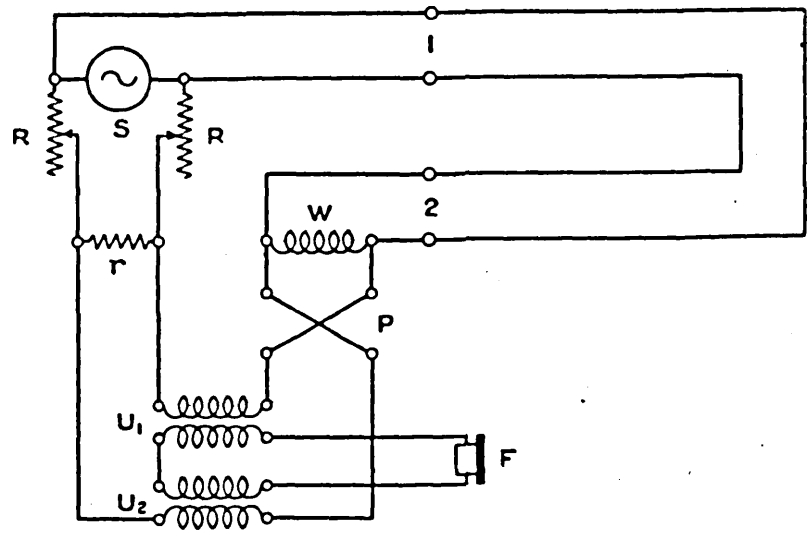


FIG. 1.

This time of propagation t denotes the time taken for an alternating current applied at one end of the line to arrive at the other end. In the case of loaded circuits the time of propagation increases as the frequency is raised; consequently the higher frequency components arrive later than those of lower frequency. This time of propagation can be measured by determining the difference in phase angle Δa for two different frequencies $\omega - \frac{\Delta\omega}{2}$ and $\omega + \frac{\Delta\omega}{2}$.

Then it is approximately true that $$t = \frac{\Delta a}{\Delta\omega} \quad \text{.....(2)}$$

This measurement can be made in a very simple manner by the balance method shown schematically in Fig. 1, where 1 and 2 represent the ends of the looped telephone circuit. The generator S, capable of supplying a variable voice frequency tone, is connected to the input of the circuit and to the potentiometer RrR.

The looped circuit is terminated by an impedance W (for example, 600 ohms) and is then connected to the potentiometer through transformers U_1 and U_2. The secondary windings are so arranged that the telephone F is effectively open circuited when no current flows in the primary windings. This state exists whenever the phase of the voltage across the resistance W coincides with that across the input 1, or is 180° out of phase if a pole changer is employed, and in addition if the magnitude of this voltage is equal to that across the potentiometer. The magnitude of the voltage can be varied by the resistance R and the phase angle of the received voltage changed by alteration of the frequency of the generator S until no sound is heard in the telephone receiver. Since the angle a increases rapidly with frequency, especially for loaded circuits, frequencies can always be found for which

$$a(\omega) = k\pi \quad \text{.....(3)}$$

where k is an integer.

Suppose ω_1 is one frequency and that ω_2 is a frequency immediately above it for which equation (3) is satisfied, also that ω_3 is a frequency immediately below ω_1, which similarly satisfies (3), then from equation (2), the time of propagation t for the frequency ω_1 is approximately given by

$$t(\omega_1) = \frac{2\pi}{\omega_2 - \omega_3} \qquad \text{.....(4)}$$

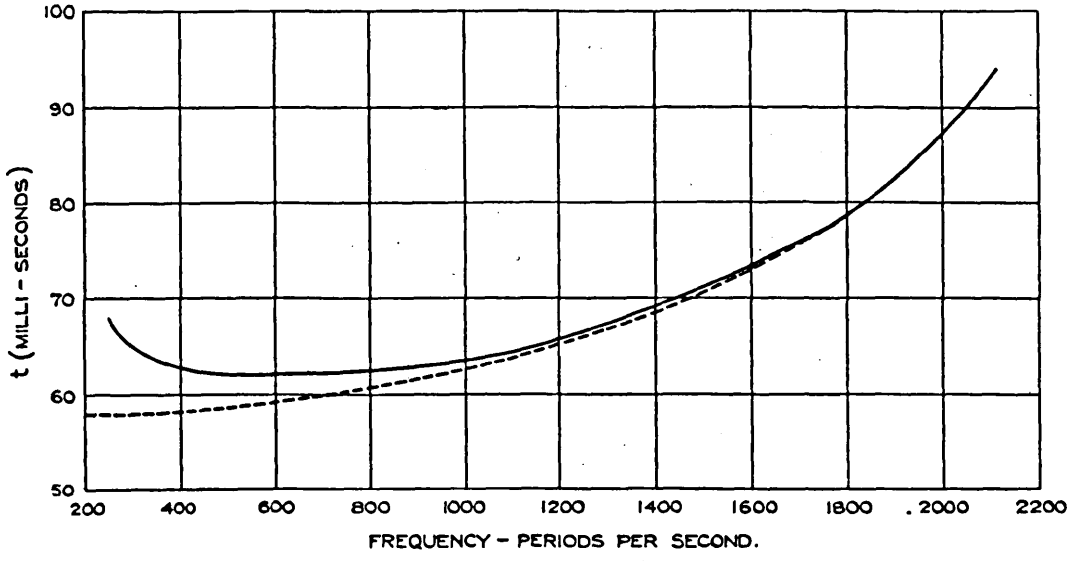


FIG. 2.

For example, Fig. 2 gives values for side circuits in a medium-heavy loaded long-distance cable with a length of 1000 km. The time of propagation increases for the lower and higher frequencies, but to a greater extent for the higher frequencies. In the upper frequency band the increase is chiefly due to the properties of loaded circuits; for this case we have approximately

$$t = \frac{2l}{S\omega_0} \frac{1}{\sqrt{1 - \left(\frac{\omega}{\omega_0}\right)^2}} \qquad \text{.....(5)}$$

where S = loading coil spacing

l = length of line.

ω_0 = cut-off frequency.

The values calculated from (5) are plotted by a dotted line in Fig. 2.

The discrepancy between measured and calculated values at the lower frequencies is due to repeating coils and repeaters.

The transitory period τ for any frequency can be deduced from the time of propagation curve by taking the time of propagation for this frequency and the time of minimum transmission, as indicated by Fig. 3.

The transitory period for the frequency f_1 is

$$\tau = t_1 - t_0 \qquad \text{.....(6)}$$

The minimum time of propagation t_0 indicates the interval after which current arrives at the end of the circuit. For the higher frequencies, we have approximately

$$\tau = \frac{2l}{S\omega_0} \left(\frac{1}{\sqrt{1 - \left(\frac{\omega}{\omega_0}\right)^2}} - 1 \right) \qquad \text{.....(7)}$$

The transitory period τ is reduced practically to a minimum if, in the transmitted band, assumed to be between 300 and 2400 p : s, the following is true :—

$$t = \frac{da}{d\omega} = \text{const.} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

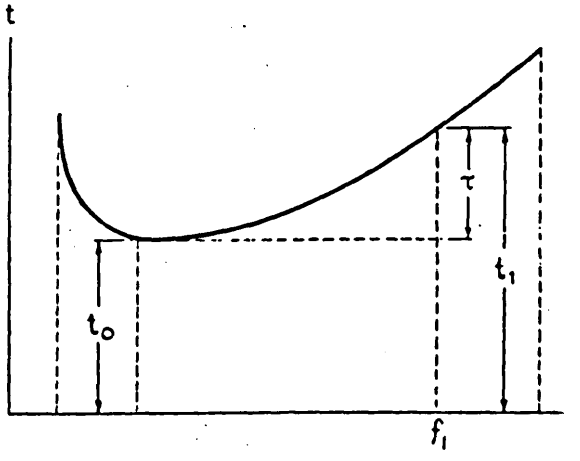


FIG. 3.

The greatest value of the transitory period τ_m in the transmitted range can be taken as a measure of the intensity of the transient phenomena; from equation (6) the period is equal to the maximum difference between the time of propagation of any two frequencies in the transmitted band. For reasons mentioned above, it is only possible to state approximately the influence of the maximum transitory period on the articulation.

It can be said, however, that the word articulation is good when

$$\tau_m < 10 \text{ to } 15 \text{ milliseconds},$$

and that transients have a disturbing effect if

$$\tau_m > 30 \text{ to } 40 \text{ milliseconds}.$$

3. Measures to Reduce the Disturbing Effects of Transients.

To reduce the disturbance due to transients, as will be seen from paragraph 2, care must be taken to make the time of propagation t as nearly as possible independent of frequency. Two methods are known to attain this end :—

(*a*) Increase of the cut-off frequency (natural frequency) by means of extra-light loading.

(*b*) The correction, by the addition of "phase compensating networks," of the variation of time of propagation with frequency.

Method (a).—For the maximum transitory period prescribed the minimum cut-off frequency required is given by the approximate formula

$$\omega_0 = \sqrt[3]{\frac{l\omega_0^2}{S\tau_m}} \qquad \text{.....(9)}$$

where l = the maximum length of a telephone circuit, and for ω_1 about 15000 can be substituted.

Given that, in general, the cost of the circuit increases with the cut-off frequency, this method is not the most economical; for example, it necessitates the use of shorter repeater sections.

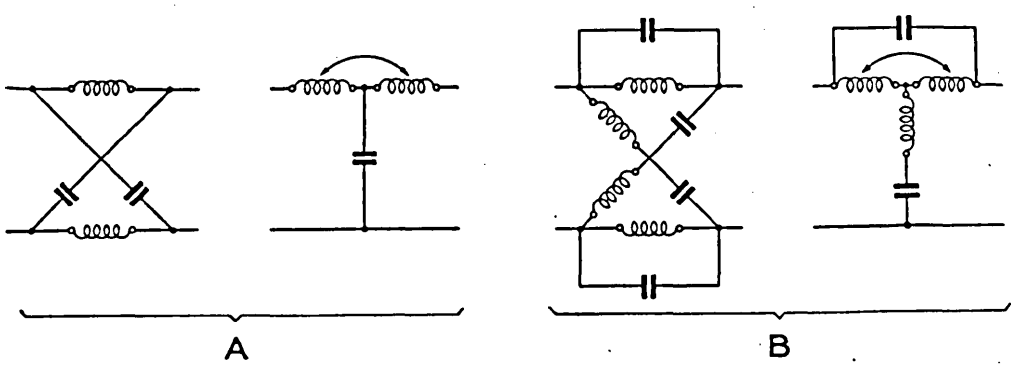


FIG. 4.

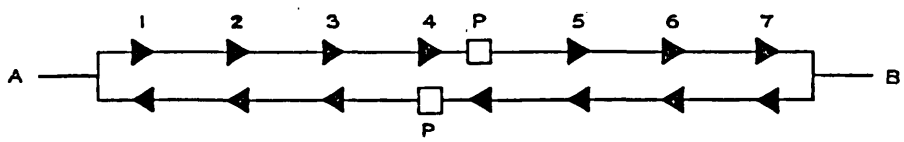


FIG. 5.

Method (b).—In order to compensate for the differences in the times of transmission of different frequencies in the transmitted range, networks which have an inverse delay frequency characteristic to that of the circuit are employed, and which preferably take the form of those shown in Fig. 4.

By a judicious choice of constants, these networks can be made to compensate the difference of propagation time to any desired precision. For example, the phase correction of a telephone circuit 950 km long is described below.

This is an actual 4-wire circuit with a cut-off frequency $\omega_0 = 17\,000$, 0.9 mm diameter conductors and a loading space S of 2 km. The repeaters are spaced, on the average, 150 km apart. Fig. 5 gives a schematic of the entire circuit.

The phase compensating networks, denoted by P, are placed at repeater station No. 4. Each network comprises a 4-wire repeater and a compensating circuit of 47 networks of type B, Fig. 4, for each direction of conversation. Fig. 6 shows the curves for the time of propagation of the telephone circuit with, and without, phase compensating networks.

In the transmission range up to 2000 p : s the transient distortion is reduced from 24 milliseconds to 8 milliseconds maximum.

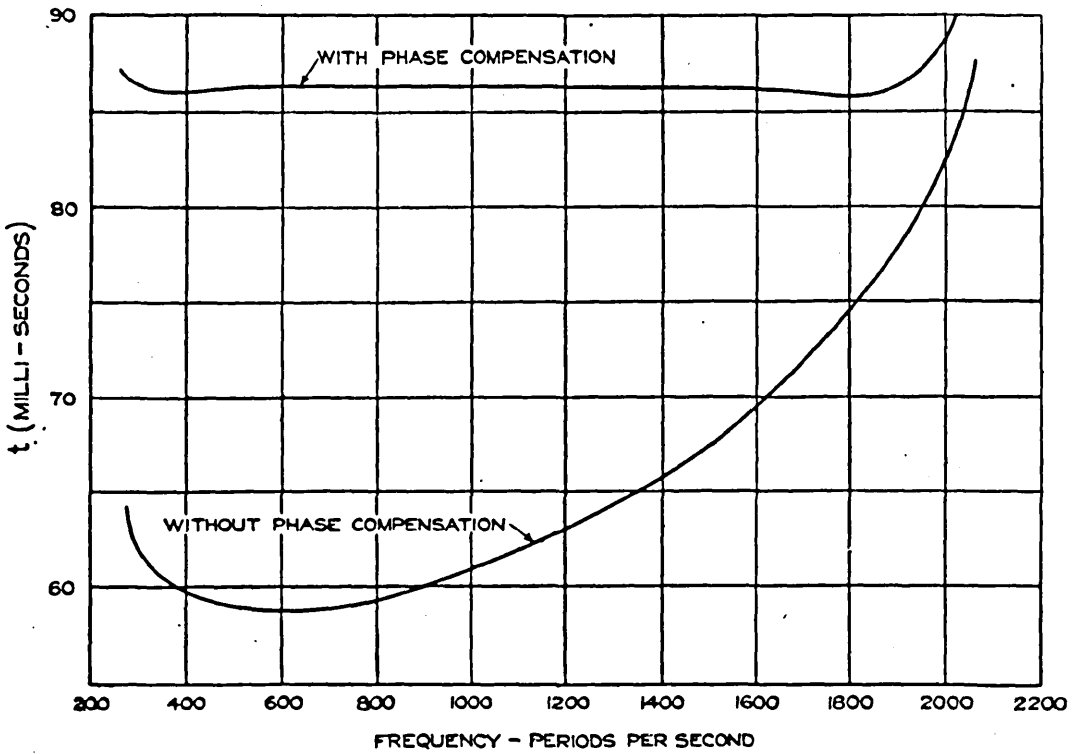


FIG. 6.

APPENDIX B.d.2, No. 5.

ESSENTIAL CLAUSES FOR A TYPICAL SPECIFICATION OF GENERAL APPLICATION TO LOADING COILS FOR INTERNATIONAL TELEPHONE CABLES.

The loading coils shall be suitable for loading both side and phantom circuits. The coils employed shall be assembled to form a unit of loading, so that when this unit is inserted in any quad, both side and phantom circuits shall be loaded. The electrical requirements hereinafter specified apply to the side and phantom circuits of such a unit of loading.

The magnetic material employed shall be of the compressed iron dust type or other approved material having equally satisfactory characteristics.

Housing.—The coils shall be encased in suitable protective cases which shall be hermetically sealed. The cases shall be waterproof and able to withstand being buried in damp ground without deterioration.

Means shall be provided for easily connecting the loading units to the main cable.

Magnetic Stability.—The magnetic stability of the core material shall be such that the inductance of a coil shall not vary by more than $\pm$ two and one-half ($2\frac{1}{2}$) per cent. after direct current of any value between zero (0) and two (2) amperes has been allowed to pass through one line winding. This test shall be made five (5) minutes after the cessation of the direct current. This is a destructive test and should be applied only to sample coils.

Inductance.—The inductance measured with a current of one (1) mA at 1800 periods per second (more exactly at $\omega = 11000$) shall be equal to the values stated for side and phantom circuits, with a tolerance of $\pm$ two (2) per cent.

Effective Resistance.—The effective resistance of the side or phantom circuit measured with a current of one (1) mA at 1800 periods per second (more exactly, at $\omega = 11000$) shall not exceed one hundred and fifty (150) ohms per henry of the specified inductance.

For all types of loading coils, the additional resistance h due to hysteresis, measured at 800 cycles and expressed in ohms per milliampere and per henry should not exceed the value given by the following provisional formula :—

$$h = 12\sqrt{L} \text{ ohms/mA/H.}$$

where L is the inductance of the loading coil expressed in henrys.*

Crosstalk.—The crosstalk in potted loading coils shall be measured with an alternating current of not less than five (5) milliamperes at 800 p : s (more exactly, $\omega = 5000$) or with speech, under the following conditions :—

The side circuits of medium-heavy units shall be terminated by non-reactive resistances of about 1600 ohms.
The phantom circuits of medium-heavy units shall be terminated by non-reactive resistances of about 800 ohms.
The side circuits of light-loaded units shall be terminated by non-reactive resistances of about 800 ohms.
The phantom circuits of light-loaded units shall be terminated by non-reactive resistances of about 400 ohms.
The input terminals of the circuit under test and the input terminals of the apparatus used for comparison shall be joined in parallel and to the source of current.

In the correcting formula corresponding to this arrangement (*see* Instructions for the Establishment and Maintenance of Circuits) 1600, 800 or 400 ohms will be taken for the minimum values of Z_1 and Z_2 as the case may be.

In cases of dispute, speech tests shall be taken as final.

The values of attenuation corresponding to the crosstalk between the various circuits in any loading coil case shall not be less, in any case, than the following values :—

Between side circuit and side circuit in the same coil unit	9 népers or 78 decibels.
Between side circuit and phantom circuit in the same coil unit	9 népers or 78 decibels.
Between side circuit and side circuit in different coil units	9·5 népers or 83 decibels.
Between phantom circuit and side circuit in different coil units	9·5 népers or 83 decibels.
Between phantom circuit and phantom circuit in different coil units ...	9·5 népers or 83 decibels.

Insulation Resistance.—The insulation resistance of any line winding of a loading coil unit against all other line windings (both in the same unit and in all other loading coil units) and the case shall not be less than ten thousand (10000) megohms. This test shall be made with a potential difference not less than one hundred (100) volts and not more than five hundred (500) volts, at a temperature of not less than fifteen (15) degrees Centigrade (approximately 60° F.).

Dielectric Strength.—The insulating material between any two line windings shall withstand, without rupture, a difference of potential with a R.M.S. value not exceeding five hundred (500) volts. This test shall be made with an alternating current of a frequency not less than fifty (50) periods per second, the voltage being applied instantaneously.

The insulation between any line winding and the case shall withstand, without rupture, a difference of potential of any effective value not exceeding two thousand (2000) volts, applied during two (2) minutes.

The maximum value of the testing voltage shall not differ by more than ten (10) per cent. from that of a true sine wave of the same R.M.S. value.

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* *See* Addendum to Appendix B.d.2, No. 5.

Unbalances to Earth.—The difference in the capacity to earth of loading coils of the two pairs of the same quad shall not exceed a value provisionally fixed at 100 $\mu\mu$F.

Variation in Inductance.—The difference of inductance of loading coils of the two pairs of the same quad, tested in phantom circuit, shall not exceed a value provisionally fixed at 0.25 per cent. of the phantom circuit inductance.

Variation in Resistance.—The difference in the direct current resistance of loading coils of the two pairs of the same quad, tested in phantom circuit, shall not exceed a value provisionally fixed at 0.20 ohm.

ADDENDUM TO APPENDIX B.d.2, No. 5.

NOTES CONCERNING THE HYSTERESIS OF LOADING COILS.

Introduction.

The additional resistance due to the hysteresis of loading coils is only one of the factors in the general problem of non-linear distortion of the whole system; nevertheless, before proceeding with the complete study of this problem, it is advisable to specify, provisionally, a maximum limit for the effect of the hysteresis of loading coils; to fix this limit, it will be necessary seriously to consider not only the additional resistance due to hysteresis, but also the total length of the circuit, the attenuation of a repeater section, the cut-off frequency and the maximum current intensity (corresponding to the maximum output power of the repeater).

It is convenient in this connection to take into consideration the attenuation due to hysteresis which takes into account these various factors and which is defined below.

In any case it seems sufficient, in order to simplify matters, to fix, for the present, a maximum limit for the additional resistance due to hysteresis expressed in ohms per milliampere and per henry measured at 800 cycles.

First Section.

Note by Dr. Vos concerning the additional attenuation caused by hysteresis.

If we consider the loaded cable equivalent to a low pass filter formed of π sections of type π as shown in Fig. 1.

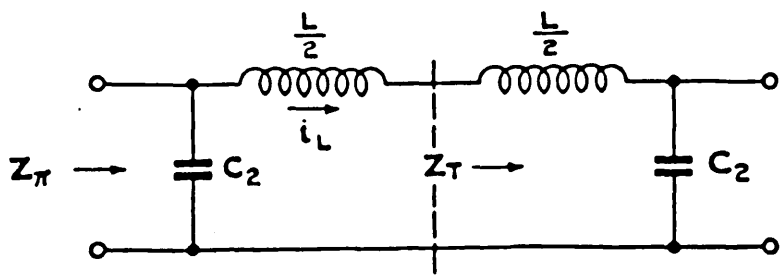


FIG. 1.

the characteristic impedance of a π section is

$$Z_\pi = \frac{Z}{\sqrt{1-\eta^2}} \quad \text{.....(1)}$$

where

$$Z = \sqrt{\frac{L}{C}} \quad \text{.....(2)}$$

and where $\eta = \frac{\omega}{\omega_0}$ = ratio between the frequency considered to the cut-off frequency. The cut-off frequency is given by the formula :—

$$\omega_0 = \frac{2}{\sqrt{LC}} \quad \text{.....(3)}$$

The characteristic impedance of the T section is

$$Z_T = Z\sqrt{1-\eta^2} \quad \ldots\ldots(4)$$

If V_1 is the voltage at the input terminals of the first section of the cable, the current i_L in the loading coil of that section will be :—

$$i_L = \frac{V_1}{Z_T + j\omega\frac{L}{2}} = \frac{V_1}{Z\sqrt{1-\eta^2} + j\omega\frac{L}{2}} \quad \ldots\ldots(5)$$

From (2) and (3) we deduce

$$L = \frac{2Z}{\omega_0} \quad \ldots\ldots(6)$$

In introducing this value in the formula (5) we obtain for the current in the first loading coil :—

$$i_L = \frac{V_1}{Z\left[\sqrt{1-\eta^2} + j\eta\right]} \quad \ldots\ldots(7)$$

The power N_1 delivered in the cable is, since $Z\pi$ is a real value and in view of formula (1) :—

$$N_1 = \frac{|V_1|^2}{Z\pi} = \frac{|V_1|^2\sqrt{1-\eta^2}}{Z} \quad \ldots\ldots(8)$$

The absolute value (Amplitude) of the current flowing through the first loading coil is thus, after (7) :—

$$|i_L| = \frac{|V_1|}{Z\sqrt{1-\eta^2+\eta^2}} = \frac{|V_1|}{Z} \quad \ldots\ldots(9)$$

From (8) can be calculated the value of $|V_1|$:—

$$|V_1| = \sqrt{\frac{N_1 Z}{\sqrt{1-\eta^2}}} \quad \ldots\ldots(10)$$

In introducing this value of $|V_1|$ in (9) for the amplitude of the current flowing through the first loading coil of the cable we obtain :—

$$|i_L| = \sqrt{\frac{N_1}{Z}} \times \frac{1}{\sqrt[4]{1-\eta^2}} \quad \ldots\ldots(11)$$

As Mr. Ulfilas Meyer showed in the *Electrische Nachrichtentechnik*, Vol. 3, 1926, p. 33, the increase in attenuation b_h in a loaded cable, due to hysteresis loss, is, in the case where these losses are not too great, given by the formula :—

$$b_h = \log_e\left(1 + \frac{\beta b}{\beta_0}\right) \simeq \frac{\beta b}{\beta_0} \quad \ldots\ldots(12)$$

In this formula, β_h is the increase in attenuation in the first section of the cable and β_0 the attenuation in the same section for a very small current in the loading coil of that section.

If b_0 is the attenuation, in the same conditions, of a repeater section of length l_1, and if the spacing of the loading coils in the cable is s, one then has

$$\beta_0 = \frac{b_0}{n} = \frac{b_0 s}{l_1} \quad \ldots\ldots(13)$$

As is well known the increase β_h of the attenuation in a section of a loaded cable is :—

$$\beta_h = \frac{R_h}{2Z}\,\frac{1}{\sqrt{1-\eta^2}} \quad \ldots\ldots(14)$$

Where R_h is the increase of the resistance due to hysteresis of the loading coil.

For a given type of loading coil the value of :—

$$b' = \frac{\left(\frac{R_h}{\omega L}\right)}{\sqrt{L}/i_L/} \quad \ldots\ldots(15)$$

is a constant characteristic which only depends upon the volume of the loading coil and the magnetic substance used for the core. Against this it is independent of the frequency, of the number of turns and of the intensity of the current (*see* the Article by Mr. Deutschmann which appeared in the *Electrische Nachrichtentechnik*, Vol. 2, 1929).

From the formula (15) we deduce

$$R_h = b' \sqrt{L}/i_L/ \omega L \quad \ldots\ldots(16)$$

By introducing the values of L and i_L given by the formulæ (6) and (11), we obtain

$$R_h = b' \sqrt{\frac{2N_1}{\omega_0}} \times \frac{\eta}{\sqrt[4]{1-\eta^2}} \cdot 2Z \quad \ldots\ldots(17)$$

from which

$$\frac{R_h}{2Z} = b' \sqrt{\frac{2N_1}{\omega_0}} \times \frac{\eta}{\sqrt[4]{1-\eta^2}} \quad \ldots\ldots(18)$$

The formula (14) for the increase of attenuation in the first section of the cable then becomes

$$\beta_h = b' \sqrt{\frac{2N}{\omega_0}} \times \frac{\eta}{(1-\eta^2)^{\frac{1}{4}}} \quad \ldots\ldots(19)$$

The additional attenuation b_h due to the hysteresis for a repeater section of cable containing n sections, will be from (12) and (13) :—

$$b_h = \frac{\beta_h}{\beta_0} = \frac{\beta_h l_1}{b_0 s} \quad \ldots\ldots(20)$$

or again considering the formula (19)

$$b_h = \frac{l_1 b'}{b_0 s} \sqrt{\frac{2N_1}{\omega_0}} \frac{\eta}{(1-\eta^2)^{\frac{1}{4}}} \quad \ldots\ldots(21)$$

If there are m repeater sections the increase in attenuation B_h due to the hysteresis for the complete circuit, will naturally be m times greater :—

$$B_h = \frac{m l_1 b'}{b_0 s} \sqrt{\frac{2N_1}{\omega_0}} \times \frac{\eta}{(1-\eta^2)^{\frac{1}{4}}} \quad \ldots\ldots(22)$$

If we designate by $l_t = ml_1$ the total length of the circuit, we obtain finally the formula

$$B_h = \frac{l_t b'}{b_0 s} \sqrt{\frac{2N_1}{\omega_0}} \frac{\eta}{(1-\eta^2)^{\frac{1}{4}}} \quad \ldots\ldots(23)$$

This formula permits therefore to calculate in a general manner, the additional attenuation due to hysteresis, that is to say the increase of the attenuation of a cable circuit due to the hysteresis of the loading coils, as a function of the total length of the cable l_t, of the attenuation b_0 for a very small current in a repeater section, of the spacing s of the loading coils, of a coefficient b' characteristic of the loading coils used, of the power N_1 delivered into the commencement of the cable, of the cut-off frequency ω_0 and of the relation η between the frequency considered and the cut-off frequency.

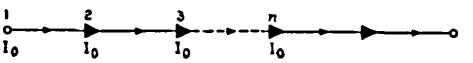
Second Section.

Note by Dr. Mayer concerning the additional attenuation due to the hysteresis.

The hysteresis coefficient E_h is defined as the additional resistance due to the hysteresis measured at 800 p : s and expressed in ohms per milliampere of current and by henry of inductance per loading coil

$$E_h = \frac{R_h}{I_0 L} \quad \ldots\ldots(1)$$

R_h designating the additional resistance due to the hysteresis for a current intensity I_0, L designating the inductance of the loading coil



For a connection consisting of n repeater sections, the additional attenuation due to hysteresis is given by the known formula :—

$$b_h = \frac{R_h}{s.R_0} \times n \quad \ldots\ldots(2)$$

R_h designates the additional resistance due to the hysteresis of the loading coils for a current at the origin I_0, sR_0 designates the ohmic resistance of a loading section of length s and n designating the number of repeater sections. (For the establishment of this formula *see* the article on " The Importance of Hysteresis in Loading Coils " by Mr. Deutschmann and published in *Electrische Nachrichtentechnik*, 1929, No. 2.)

If b is the attenuation of a repeater section, β the kilometric attenuation and l the total length of the circuit, we have :—

$$b \times n = \beta \times l$$

or

$$n = (\beta \times l) : b \quad \ldots\ldots(3)$$

We have besides

$$\beta = \frac{R_0}{\omega_0 L} \quad \ldots\ldots(4)$$

where ωo is the cut-off frequency.

From (3) and (4) we deduce

$$n = \frac{R_0 \times l}{b \times \omega_0 \times b} \quad \ldots\ldots(5)$$

from which results for b_h

$$b_h = \frac{R_h \times l}{S.b.\omega_0.L} \quad \ldots\ldots(6)$$

From this the relation between E_h and b_h is deduced

$$E_h = b_h \frac{S.b.\omega_0}{l.I_0} \quad \ldots\ldots(7)$$

The foregoing formulæ are approximate; their accuracy is sufficient for the case considered.

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concerning questions of transmission, maintenance and supervision of lines and installations.

ABBREVIATIONS.

(a) German Publications.

A. f. E.	Archiv für Elektrotechnik.
E. F. D.	Europäischer Fernsprechdienst.
E. N. T.	Elektrische Nachrichtentechnik.
E. T. Z.	Elektrotechnische Zeitschrift.
F. i. W.	Das Fernsprechen im Weitverkehr.
Fk.	Das Fernkabel.
M. TRA.	Mitteilungen aus dem Telegraphentechnischen Reichsamt.
Ph. Z.	Physikalische Zeitschrift.
S. Z.	Siemens Zeitschrift.
T. u. F. T.	Telegraphen und Fernsprechtechnik.
W. V. S. K.	Wissenschaftliche Veröffentlichungen aus dem Siemenskonzern.
Z. f. t. P.	Zeitschrift für technische Physik.

(b) English Publications.

B. repr.	Bell reprint.
B. S. T. J.	Bell System Technical Journal.
B. T. Q.	Bell Telephone Quarterly.
Elec.	The Electrician.
El. Com.	Electrical Communication.
El. Rev.	Electrical Review.
El. W.	Electrical World.
Eng.	Engineering.
G. E. R.	General Electric Review.
I. P. O. E. E.	Institution of Post Office Electrical Engineers.
J. A. I. E. E.	Journal of the American Institute of Electrical Engineers.
J. A. S. A.	Journal of the Acoustical Society of America.
J. Fr. I.	Journal of the Franklin Institute.
J. I. E. E.	Journal of the Institution of Electrical Engineers.
P. O. E. E. J.	The Post Office Electrical Engineers' Journal.
Pr. I. R. E.	Proceedings of the Institute of Radio Engineers.
Pr. Ph. S.	Proceedings of the Physical Society of London.
W. P.	World Power.
W. W. & R. R.	Wireless World and Radio Review.
T. A. I. E. E.	Transactions of the American Institute of Electrical Engineers.

(c) French Publications.

A. P. T. T.	Annales des Postes, Télégraphes et Téléphones.
B. P. T. T.	Bulletin de l'Administration française des Postes, Télégraphes et Téléphones.
B. S. F. E.	Bulletin de la Société française des Electriciens.
B. S. I. E.	Bulletin de la Société des Ingénieurs électriciens.
B. Techn. T. T. Suisses	Bulletin technique de l'Administration des Télégraphes et Téléphones suisses.
Ecl. Elec.	Eclairage électrique.
Gén. Civ.	Génie civil.
Ind. Elec.	Industrie électrique.
Ind. V. F. et T. A.	Industrie des Voies ferrées et des Transports automobiles.
Journ. Phys. et Rad.	Journal de Physique et le Radium.
Journ. Télégr.	Journal télégraphique (publié par le Bureau International de l'Union Télégraphique).
Lum. Elec.	Lumière électrique.
Onde Elec.	Onde électrique.
Q. S. T. et Rad. Elec.	Q. S. T. française et Radioélectricité réunis.
Rad. Elec.	Radioélectricité.
R. G. E.	Revue générale de l'Electricité.
R. T. T. et T. S. F.	Revue des Téléphones, Télégraphes et T.S.F.
Techn. Mod.	Technique moderne.
T. S. F. Mod.	T.S.F. moderne.

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(*g*) Co-ordination of Radio Telephony and Telephony.

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V.—QUESTIONS OF TRAFFIC, OPERATION AND TARIFFS.

A.—General.

B.—Various classes of calls and facilities to be offered to the public.

C.—Methods of operating.

D.—Rates and tariffs.

E.—Traffic statistics.

Note.—Among the Recommendations given hereafter, some replace former Recommendations; the modifications to previous Recommendations are indicated by means of vertical lines in the margin.

A.—GENERAL.

RECOMMENDATION No. 4.*

Establishment of the Nomenclature of the International Circuits and the Schematic Plan of the Cables.

I. Form under which the nomenclature of the international circuits should be arranged.†

The International Consultative Committee, in agreement with the International Bureau of the Telegraph Union, Unanimously advises :—

That, in future, the nomenclature of existing and projected international circuits, kept up to date and published by the International Bureau of the Telegraph Union, should be arranged in accordance with the following indications :—

The nomenclature of the international telephone circuits should be presented in the form of the following table comprising 11 columns (p. 215).

This nomenclature should be arranged in such a manner that a complete idea of the composition of each international circuit may be obtained without having to consult different pages of the nomenclature for the same circuit.

All the international circuits (*excluding circuits connecting frontier towns*) are arranged in alphabetical order according to their official designation.

Column 1—Designation of the Circuits.

Each international circuit is designated by the names of the two terminal exchanges followed by the number of the circuit, the names of the exchanges included in the designation of the circuit being those which figure on the official geographical plans of their respective countries, the two names being placed in alphabetical order, *e.g.*, Berlin-London 3.

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* This Recommendation replaces Recommendation No. 4 on pp. 554 to 558 of the *Livre Jaune* (English Edition, pp. 332-335).

† The International Consultative Committee recommends that each terminal exchange to which are connected international circuits, other than frontier circuits, should be provided with a nomenclature of international circuits.

Column 2—Countries.

Column 2 should include the names of the countries on whose territory the different sections of the circuit lie, in the order in which the circuit crosses them, going from one terminal exchange to the other terminal exchange, *i.e.*, in geographical order: *e.g.*, for circuit Berlin-London 3: Germany-Holland-Great Britain.

Column 3—Length of Successive Homogeneous Sections in each Country (Km).

Column 3 should include the length of each homogeneous section of the circuit expressed in kilometres.

Column 4—Type of Construction.

The type of construction of the various sections of the circuit should be shown as follows:—

Open-wire line	la
Underground cable	st
Aerial cable	ca
Submarine cable	sm

Column 5—Nature of Circuits.

The nature of the different sections of the circuit should be shown as follows:—

Two-wire side (or physical) circuit	2f.
Two-wire phantom circuit	2f. comb.
Four-wire side (or physical) circuit	4f.
Four-wire phantom circuit	4f. comb.

Column 6—Diameter of Conductors (mm).

The diameter of the conductors should be expressed in millimetres for each section of the circuit.

Column 7—Coil Loading or Continuous Loading.

This column should indicate concise information on the type of coil loading or continuous loading of each section of the circuit. If the coil loading conforms to the recommendations of the International Consultative Committee, it is sufficient to show the method chosen in the following way: "Method 1*a*," "Method 1*b*" or "Method 2." If the methods of coil loading differ from the International Consultative Committee's recommendations, the inductance per kilometre and the coil spacings should be shown:—

$$e.g. \begin{cases} 103 \text{ mH/km} \\ D = 1.66 \text{ km} \end{cases}$$

In the case of continuously loaded cables the inductance per kilometre followed by the word "Krarup" should be included, *e.g.*, 13 mH/km Krarup. If a section of the circuit is neither coil loaded nor continuously loaded, this should be indicated in column 7 by "Non-loaded."

Column 8—Cut-off Frequency (p : s).

In this column the critical cut-off frequency (or frequency limit) should be expressed in periods per second for each loading section of the circuit.

Column 9—Equivalent (at 800 p : s).

This column is divided into two parts. On the left the transmission equivalent at 800 periods per second is shown in népers, and on the right this equivalent is shown in decibels. For each circuit the nomenclature must give both the number of népers and the number of decibels.

Column 10—Names of Intermediate and Terminal Repeater Stations

The names of intermediate or terminal repeater stations shown in this column should be grouped together by countries.

Column 11—Remarks.

It is desirable to include in this column, for each of the terminal exchanges, reference to the use of cord circuit repeaters for connecting two-wire—two-wire, two-wire—four-wire, and four-wire—four wire as follows :—

$$\text{Cord circuit repeaters } \frac{2f}{2f} \quad \frac{2f}{4f} \quad \frac{4f}{4f}$$

The nomenclature of the international telephone circuits should be set up in future in accordance with the table shown in Appendix No. 1.

After the list of circuits in alphabetical order there should be given a general summary showing for connections between two certain countries, the number of circuits existing in each direction, including the circuits connecting the neighbouring networks of the frontier, as shown in Appendix No. 2.

Finally, following this, a list should be given (by countries and in each country by alphabetical order) of the terminal exchanges of the international circuits which have several designations in their own countries. The form of this list is shown in Appendix No. 3.

Note.—The International Bureau of the Telegraph Union will determine, as the need arises, suitable dates for publishing a supplement to the last edition of the nomenclature of the international circuits or a new edition of this nomenclature.

Furthermore, in setting up this nomenclature, if the characteristics of the different circuits connecting the same two towns are identical these characteristics will appear once only.

APPENDIX 1.

FORM OF TABLE FOR ESTABLISHING THE NOMENCLATURE OF THE INTERNATIONAL CIRCUITS.

Designation of the Circuits.	Countries.	Length of successive homogeneous Sections in each Country. (Km)	Type of Construction.	Nature of Circuits.	Diameter of Conductors. (mm)	Coil loading or continuous loading.	Cut-off frequency. p : s.	Equivalent at 800 p : s.		Names of Intermediate and Terminal Repeater Stations.	Remarks.
								népers.	decibels.		
1.	2.	3.	4.	5.	6.	7.	8.	9.		10.	11.
Berlin-London 3	Germany	4	st	2f	2	Non-loaded	—			Berlin, Friesack, Perleberg, Vellahn, Hambg, Rotenbg, Bassum, Bohmte, Münster, Wesel.	C.C. rep. 2f 2f 4f / 2f 4f 4f
	,,	582	st	4f	0.9	Method 2	400				
	,,	193	st	4f	0.9	103 mH/km D=1.66 km	3 500				
	Holland	20	st	4f	0.9						
	,,	119	st	4f	1.29	30 mH/km D=1.65 km	5 700			Arnheim Rotterdam Domburg.	
	,,	65	st	4f	1.23	25 mH/km D=1.84 km	5 700	1.0	8.7		
	,,	93	st	4f	1.8	100 mH/km D=1.761 km	2 790				
	,,	153	sm	2f	2.0	13 mH/km Krarup				Aldeburgh Marks Tey	C.C. rep. 2f 2f 4f / 2f 4f 4f
	Gt. Britain ,,	73	st	4f	0.9	50 mH/km D=1.83 km	3 920				
	,,	82	st	4f	1.27	65 mH/km D=2.72 km	2 340				
		1 384									

APPENDIX 2.

Form of the General Summary of the International Circuits to be attached to the Nomenclature of the International Circuits.

Telephone Connections between Germany and other Countries.

1. **Connections Germany-Belgium.**

Exchanges in Direct Connection.	No. of Ccts.
Aix-la-Chapelle—Liège...	2
Aix-la-Chapelle—Verviers	3
Berlin—Antwerp	1
Berlin—Brussels	1
etc.	

2. **Connections Germany-Denmark.**

Berlin—Copenhagen	3
Hamburg—Copenhagen	4
etc.	

Telephone Connections between Belgium and other Countries.

1. **Connections Belgium-Germany**

Exchanges in Direct Connection.	No. of Ccts.
Antwerp—Aix-la-Chapelle	1
Antwerp—Berlin	1
Brussels—Berlin	1
Brussels—Frankfurt (Main)	1
Liège—Aix-la-Chapelle	2
Liège—Cologne	1
etc.	

2. **Connections Belgium-Austria.**
etc.

APPENDIX 3.

Form of List of Terminal Exchanges having several designations, to be attached to the Nomenclature of International Circuits.

Name of Country.	Official Designation of the Exchanges.	Unofficial Designation of the Exchanges.
Belgium	Kortryck	Courtrai
Switzerland	Genève	Genf, Ginevra

II. Form under which the Schematic Plan of the Cables should be set up.

The International Consultative Committee, in agreement with the International Bureau of the Telegraph Union, Unanimously advises :—

That, in future, the plan showing the existing and projected cables, kept up to date and published by the International Bureau of the Telegraph Union, should be set up in accordance with the following :—

In view of the rapid development of the European network of telephone cables, a plan should be re-edited at least every two years.

On one plan there should only be shown the cables already in service or those which it is known definitely will be in service before a new publication of the plan.

The distinction between a central exchange with a repeater station and a repeater station only is of little interest and should not be shown.

On the other hand, on each line representing a cable a reference number should be shown.

The reference number of a cable should correspond to a similar number on a list attached to the plan, on which should be indicated :—

The type of cabling :—

D.M. (Dieselhorst Martin) or Quadded Cable.
E. Star Quadded Cable.
P.E. Four-pair Star Quadded Cable.

Also for each type of quad ; the number of quads, the diameter of the conductors and the type of loading. These indications should be given in the following form :—

Reference No. of the Cable.	Type of Cabling, total number of quads, loaded or non-loaded for the different homogeneous sections of the cable.	Different Classes of Loaded Quads.			Remarks.
		No. of Quads of the class concerned.	Diameter of the Conductors.	Type of Loading.	
1.	2.	3.	4.	5.	6.
4	**Paris—Sélestat**				
	Paris—Nancy D.M. 94	12	1·3	non-loaded	Aluminium screened.
		16	1·3	177/107–1830	
		24	0·9	44/25–1830	
		42	0·9	177/107–1830	
	Nancy—Sélestat D.M. 94	12	1·3	non-loaded	Aluminium screened.
		16	1·3	177/107–1830	
		18	0·9	44/25–1830	
		46	0·9	177/107–1830	
8	**Boulogne—Canterbury** E. 7	7	2	Krarup mH/km	Phantom circuits used.
11	**Arnheim—Utrecht** E. 117	82	1·29	155–1630	Phantom circuits not used.
		22	1·29	50–1630	
		13	1·67	155–1630	

RECOMMENDATION No. 4a.*

Establishment of a Plan of European International Circuits specially designed or arranged for Music Transmission.

The International Consultative Committee—

Considering :—

That one should not be expected to indicate by a special mark, on the schematic plan of European international telephone cables, the cables which contain circuits specially established or arranged for

* This Recommendation should be included between Recommendations No. 4 and No. 5 on p. 560 of the *Livre Jaune* (English Edition, p. 336).

music transmission, since the plan in question is of the form which renders it unwieldy and inconvenient for this purpose.

Unanimously advises :—

1. That it is advisable for each country to draw up a separate plan of circuits specially established or arranged for music transmission.

2. That, on this plan, the different circuits should be represented in the following manner (*see* form below).

Full line-cable circuits specially established for music transmission (circuits transmitting effectively a band of frequency from 50—6400 p : p : s).

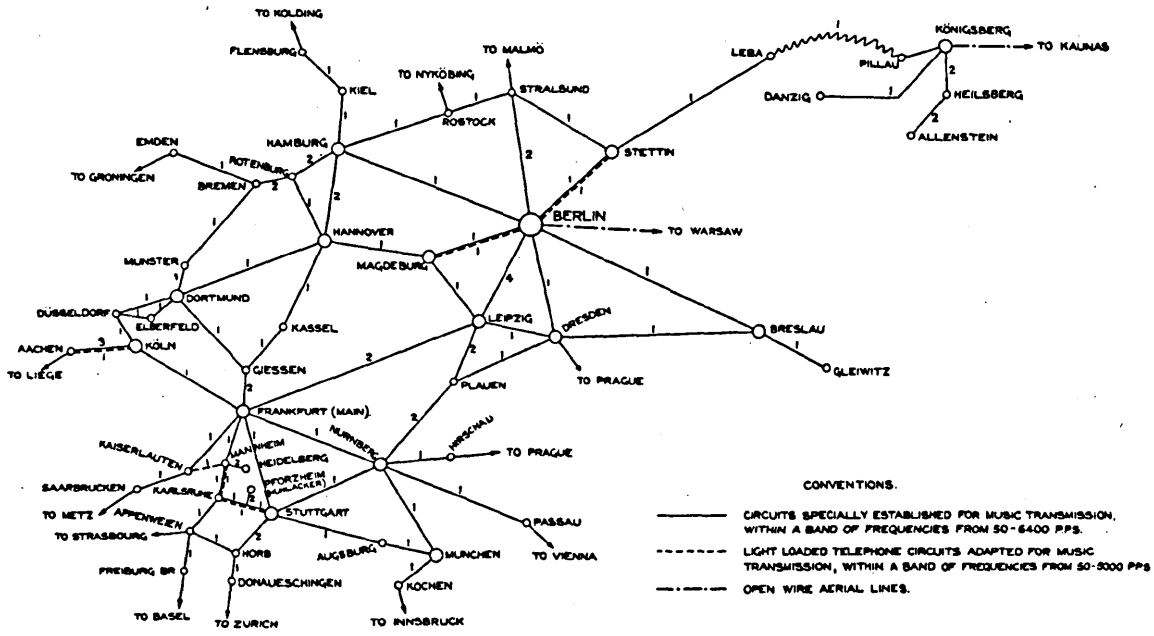
Dotted line-cable circuits arranged for music transmission (circuits transmitting effectively a band of frequency from 50—5000 p : p : s).

Chained dotted-line—aerial circuits.

For each line, the number of circuits used for music transmission will be indicated on the plan.

3. That the International Bureau of the Telegraph Union collect the various plans set up by the different countries in order to establish a " Plan of European International Circuits specially established or arranged for Music Transmission."

TYPICAL DIAGRAM OF EUROPEAN INTERNATIONAL CIRCUITS SPECIALLY ESTABLISHED OR ARRANGED FOR RADIO-BROADCAST TRANSMISSIONS.



RECOMMENDATION No. 9.*

Emergency Lines.

The International Consultative Committee—

Considering :—

That it is desirable to take steps so that, in case of interruption of an international channel, the traffic normally carried by that channel may be maintained;

That the use of emergency lines in exceptional cases should not modify the charges for calls,

Unanimously advises :—

1. That Administrations concerned should come to an understanding as to the line or lines to be used as emergency lines in case of interruption of the normal service, and that emergency lines should be chosen from those which cross countries not normally used;

2. That the list of such lines should be revised each year at the Plenary Session of the C.C.I.;

3. That the rates to be charged when these lines are utilised should be the same as for normal lines;

4. That the rates allotted to each Administration should provisionally be divided as follows :—

Total rate obtained by adding the rates appertaining to the first zone in each terminating country and, where necessary, to parts of the countries traversed.† The total rate is then divided between the respective Administrations in the following manner :—

Each terminating Administration receives a proportional part corresponding to its share of the first zone with consideration of the emergency line.

Each transit Administration receives a proportional part of the rates to which it is normally entitled for conversations using normal service circuits.

5. That the Administrations give instructions with regard to the constitution of the direct emergency lines when the network layout allows it, and when impossible the head of the terminal exchange will endeavour to deal with the traffic in such a manner that the maximum waiting time as laid down by the C.C.I. is not exceeded (Recommendation No. 2, p. 552, of " Livre Jaune ").

Method of Use of Emergency Line.

Considering the line Glasgow (third English Zone)—Zürich, the normal line is made up of a direct circuit London—Zürich passing through France. In case of interruption, the *auxiliary lines* crossing the same countries, *i.e.*, first of all lines connecting Great Britain and Switzerland via France directly, but, should these also be interrupted, the circuits London—Paris, and Paris—Switzerland, should be considered. In these two cases the division of rates between the Administrations is not changed. If the auxiliary lines are also interrupted, an *emergency line* (lines crossing countries which are not used for the normal line nor the auxiliary lines) for instance, one made up of circuits London—Frankfurt (crossing Belgium) and Frankfurt—Zürich should be employed. The rate of distribution of the charges will be obtained by adding :—

(*a*) The terminating section of the British first zone for the connection Great Britain—Switzerland.

(*b*) The terminating Swiss portion (for the Swiss portion consists of only one zone), for the connection Great Britain—Switzerland.

(*c*) The French transit portion for the connection Great Britain—Switzerland.‡

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* This text replaces the one under the same title which appears on pp. 569-571 of the *Livre Jaune* (English Edition, pp. 341-342).

† It is understood that the amount of the terminal charge beyond the first zone charge is still payable to the terminal Administration concerned.

‡ Great Britain will retain (or receive, in the case of incoming calls) the difference between its third and first zone charges for the connection Glasgow-Zürich.

This amount will be divided as follows :—

Great Britain's share will be proportional to its first zone for the connection Great Britain—Germany.

Belgium's share will be proportional to its transit portion in the connection Great Britain—Germany.

Germany's share will be proportional to the amount received normally for London—Frankfurt and Frankfurt—Zürich connections.

Switzerland's share will be proportional to the terminating portion in the connection Germany—Switzerland.

Note.—When several normal lines exist between two given countries and these lines pass through various countries, the above arrangement does not hold good. Administrations and Operating Companies should reach an understanding in the matter.

B. VARIOUS CLASSES OF CALLS AND FACILITIES TO BE OFFERED TO THE PUBLIC.

RECOMMENDATION No. 14.*

Subscription Calls during the heavy traffic period.

The International Consultative Committee—

Considering :—

That it is advisable, when traffic conditions permit, to develop the service of subscription calls.

Unanimously advises :—

1. That during heavy traffic periods, except during the hours of maximum traffic (to be determined by the heads of the terminal exchanges concerned), subscription calls should be allowed without a time limitation at the ordinary call rates on one of the two conditions specified below :—

(*a*) That circuits are available.

(*b*) That the average delay at the time fixed for the call does not exceed the following, according to the terms of the subscription :—

15 minutes for circuits under 500 km.
30 ,, ,, ,, between 500 and 1000 km.
45 ,, ,, ,, exceeding 1000 km.

2. That subscription calls allotted during heavy traffic periods when the above mentioned conditions are not fulfilled should be charged at twice or three times the normal rate according to the average delay on the particular international circuit at the time the subscription call should be set up, the interested Administrations agreeing on this for each particular connection.

3. That there is no necessity to modify the conditions already laid down for subscription calls during periods of light traffic.

RECOMMENDATION No. 15.†

Agreement to be concluded between Exchanges and Subscribers for the exchange of Fixed-Time Calls.

The International Consultative Committee—

Considering :—

That the legal or administrative clauses which accompany a subscription contract can differ according to the country, but that it is necessary to include in all contracts of this kind a certain amount of indispensable information to give the contract its corresponding legal status;

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* This recommendation replaces Recommendation No. 14 on pp. 580 and 581 of the *Livre Jaune* (English Edition, p. 347).

† This recommendation replaces Recommendation No. 15 on pp. 581-584 of the *Livre Jaune* (English Edition, pp. 347-349).

Unanimously advises :—

That the Administrations, in preparing the subscription contracts, should be guided by the following typical form.

The International Consultative Committee—

Considering :—

That, in accordance with the Regulations of International Service, Brussels Revision, 1928, Section H, § 8, (2) the times and duration of subscription calls, after having been fixed by agreement between the offices interested, are confirmed in writing;

Unanimously advises :—

1. That the arrangements in connection with the reception of calls by subscription should be made by telephone during the hours of light loads between the terminal exchanges.

2. That the written confirmation should be drawn up in accordance with the following formula :—

Confirmation of the arrangement relating to subscription calls made the.....19.....

A call of.....minutes must be established every day, Sundays and public holidays excluded,* at..... o'clock (legal time of.....†) between subscriber No.....at.....and subscriber No..... at.....on and after.....19.....

For confirmation

.....exchange.....19.....

Signed.....

3. That this confirmation should be sent by the originating terminal exchange to the other interested terminal exchanges, the latter communicating, as the case may be, with the other exchanges in their country which are interested in the establishment of the communication.

Typical Form of Subscription Contract (Front).

The Telephone Administration of.....(country of origin).
Subscription for International Telephone Service.

The undersigned.....residing at.....agrees to pay until further notice, according to the conditions set out overleaf, the monthly subscription detailed below, beginning from.....

Network and Telephone Number.		Time at which the connection is to be established.‡	Duration of Call.	Is the connection to be established on Sundays and public holidays ?	Monthly Tariff.
Caller.	Called.				
	Made at.....the.....				

* The mention of " Sundays and public holidays excluded " may be omitted if necessary.

† Name of country where subscription is made.

‡ Legal time of the country where the subscription is made.

Typical Form of Subscription Contract (Back).

General Conditions of the Subscription.

ART. I.—The subscription calls take place daily between the the same stations at the same time, as agreed in advance.

The duration of the subscription is for at least one month; it may be prolonged from month to month, by mutual consent.

The subscription can be cancelled by either party by notice given eight days before the expiration of the current month of the subscription.

ART. II.—The subscription calls must exclusively concern the personal business of the correspondents or that of the establishments.

ART. III.—The minimum duration of a subscription call is three minutes. Calls of a greater duration than six minutes can be allowed if the normal traffic on the circuits used permits this.

ART. IV.—Subscription calls are subject to the following charges :—

(*a*) During the period of high traffic* : half the unit rate.
(*b*) During other periods† : double or treble‡ the unit rate.

The amount of subscription is calculated on a mean duration of 30 days. However, in connection with the subscription for exchange of conversations during the period of heavy traffic, the monthly rate can be calculated on the basis of 25 days should the subscriber give up the use of his subscription on Sundays and public holidays corresponding to Sundays in his own country.

The amount of subscription is payable in advance.

ART. V.—The subscription can be contracted from any date, but the monthly period only comes from the first of each month. The amount of subscription corresponding to the first monthly period may be increased, if necessary, by the part of the subscription corresponding to the period between the date of its coming into force and that of the commencement of the monthly period.

ART. VI.—The connection is to be officially established between the two stations indicated on the contract at the exact time agreed upon, unless another conversation is in progress or a demand for an urgent Government call is on hand.

It is to be officially disconnected at the expiration of the time allowed for each call if the subscribers have not already given the signal that the conversation is finished. However, the subscribers may continue their conversation if there is no other demand on hand, the additional conversation to be considered as an ordinary private call, and charged for a minimum of three minutes.

ART. VII.—No compensation should be given and no refund made if, by the act of the subscribers, the call has not taken place or has not had its prescribed duration.

A subscription call which for some cause attributable to the telephone service, cannot be effected or has not lasted for the prescribed duration, shall be replaced or compensated for by a call of a duration equivalent to the unused period; if possible, before the end of the same tariff period.

If the call cannot be replaced or if compensation cannot be given, a refund is made on the demand of the subscriber. The refund is fixed at one twenty-fifth or one-thirtieth of the monthly amount of the subscription if the conversation has not taken place, or that part of the same fraction of the monthly subscription corresponding to the time lost if the conversation has been curtailed.

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* From.....(time) to.....(time).
† From.....(time) to.....(time).
‡ Delete either "double" or "treble."

ART. VIII.—If the use of a circuit for radio transmission necessitates special supervision or the addition of special arrangements or modifications to the existing apparatus, the additional expense as a result thereof, as well as those due to resetting the circuit for normal operation after each radio transmission, will be borne by the Broadcasting Company contracting this agreement.

RECOMMENDATION No. 17.*

Occasional Calls at Fixed Time.

The International Consultative Committee—

Considering :—

That, amongst the numerous international connections, fixed-time calls are allowed by subscription during hours of heavy traffic;

Unanimously advises :—

That in these connections occasional fixed-time calls should be allowed.

Considering :—

That it is desirable to avoid the introduction of such calls causing difficulties in the operation of the general service;

Unanimously advises :—

That occasional fixed-time calls should be demanded at least half an hour in advance. However, for such calls necessitating important modifications to lines or equipment, a longer time in advance should be required for the demand (for example, at least an hour).

Considering :—

That it is necessary to specify the nature of the calls that have priority over fixed-time calls;

Unanimously advises :—

That fixed-time calls should be established at the time specified unless a conversation is already in progress, in which case the fixed-time call is delayed until the end of this conversation or unless a lightning or an urgent Government call is waiting, in which case the latter have priority. If several fixed-time calls are demanded for the same circuit at the same time they should be established in the order in which they were received at the controlling exchange.

Considering :—

That these fixed-time calls have priority over private calls.

Unanimously advises :—

1. That occasional fixed-time calls, with the exception of occasional international fixed-time calls of long duration during periods of light traffic (see Recommendation No. 18), be subject to a tax equal to three times that of an ordinary call of the same duration and during the same rate period, plus one-third of the unit charge for the same ordinary conversation, with a minimum of 0.50 Frs. for this additional charge.

2. That, in the case of refusal by the calling or called subscriber, or no reply from the calling subscriber when challenged by his exchange to take this fixed-time call (final call), the ordinary regulation for refusal or no reply is applied, that is, the rate for one minute of ordinary conversation only is charged (see Recommendation No. 54).

* This recommendation replaces Recommendation No. 17 on pp. 585-586 of the *Livre Jaune* (English Edition, pp. 349-350).

3. That it is advisable to allow occasional fixed-time calls with préavis or avis d'appel. In this case, the rate for an urgent conversation with préavis or avis d'appel is charged, the special extra charge (one-third of the rate for an ordinary call) for occasional fixed-time calls not being made.

4. That should the calling subscriber cancel his demand for an occasional fixed-time call with préavis after this préavis has been transmitted, the charge for the préavis only is made. If the calling subscriber cancels his fixed-time call without préavis before he has been challenged to take the call (final call) no charge is made.

RECOMMENDATION No. 18.*

Occasional International Conversations of Long Duration at Fixed Times effected during hours of Light Traffic.†

The International Consultative Committee—

Considering:—

That it is important to increase as much as possible the occupied time of circuits during the hours of light traffic where this can be done without an increase of staff.

That long conversations increase the revenue of the circuits.

That, on the other hand, the supplementary charge made for occasional fixed-time calls of long duration is insignificant compared with the total tariff for these conversations.

Unanimously advises:—

1. That it is desirable to allow occasional fixed-time conversations of long duration during the period of light traffic, providing this does not interfere with the general service.

2. That it is desirable to allow a reduced tariff for occasional fixed-time conversations requested for a minimum duration of one hour, and to be established during the period of light traffic.

3. That this tariff should be fixed at half the unit charge and that the duration of the conversation exceeding one hour should be charged per minute.

4. That in accordance with the General Regulations the charges for these conversations should be paid by the caller.

C.—METHODS OF OPERATION.

RECOMMENDATION No. 23.‡

Modification to the Demands for Calls at the Request of the Caller.

The International Consultative Committee—

Considering:—

Paragraph 6, of Section L, of the International Regulations (Revision of Brussels), which allows a demand for a call to be cancelled up to the moment when the originating subscriber is called by his exchange.

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* This text replaces Recommendation No. 18 on pp. 586-588 of the *Livre Jaune* (English Edition, pp. 350 and 351).

† The C.C.I. has not thought it necessary to propose regulations for occasional fixed time conversations of long duration during the period of heavy traffic and requiring either the addition of special technical arrangements or modifications in the normal adjustment of existing apparatus. However, if occasional fixed-time calls of long duration which do not necessitate modifications to the normal conditions of transmission are requested for the period of heavy traffic, the Administrations and Operating Companies concerned should agree directly as to whether they will be allowed, and what rate may be charged.

‡ This recommendation replaces Recommendation No. 23 on pp. 596 and 597 of the *Livre Jaune* (English Edition, pp. 355-356).

Considering :—

That it is better to reduce, as much as possible, the number of cancellations and especially to avoid those which arise when the calling or called subscriber temporarily changes his location in the network.

Unanimously advises :—

1. That, in the international service, the caller should be allowed, so long as he has not been called by his exchange, to change either the calling number or the called number within the limits of the respective networks.

2. That this facility should be free; however, the originating Administration can, if it thinks necessary, levy a special charge to compensate for the modification of the demand for a call, this charge not entering into the international accounts.

Considering, on the other hand :—

Paragraph 8, Section L, of the International Regulations (Revision of Brussels, 1928), allowing the caller to specify that the call be set up after a certain delay.

Considering :—

That cancellation may be avoided if the caller can specify that the call should not be established during a definite period of the same day or if the demand for a call can be brought forward beginning from a definite time on the same day.

Advises :—

1. That the caller should be able, up to the moment when he is called by his exchange, to specify that the call be not established within a definite period and if the time for setting up this call has not yet reached the beginning of this period, the time considered as registration time for the call is that of the end of the specified period.

2. That the originator of an international call should be able, up to the moment when he is called by his exchange, to carry forward his demand for a definite time of the same day; in this case the time first mentioned as the registration time of the demand is replaced by the new time indicated.

3. That these facilities should be free; however, an originating Administration can levy a special charge to recompense for the extra work, this charge not entering into the international accounts.

Considering, further, with regard to conversations with préavis and avis d'appel:

That modifications to demands for a préavis or avis d'appel already transmitted to the terminal exchange are not frequent.

That it is advisable to simplify as far as possible the regulations for charging.

That, moreover, the modifications requested by the caller often result in a call being established which otherwise would have been cancelled.

Considering, however :—

That if, in principle, the charge for a préavis pays, on an average, for the work done in sending the préavis and obtaining the required subscriber, the charge for an avis d'appel cannot be considered as paying for sending more than one message.

Unanimously advises :—

1. That the modification of a demand for a call with préavis or avis d'appel should be allowed free of charge so long as the caller has not been called by his exchange except, in the case of avis d'appel, when the modification necessitates a second message: under these circumstances the charge for avis d'appel and, if necessary, the messenger surcharge, should be doubled. However, the originating

Administration may, in all cases, make a special charge to pay for the extra clerical work involved, this extra charge not appearing on the international accounts.

2. That the change of a demand for an ordinary call into a demand for an urgent call, or vice-versa, be allowed free of charge, the time of this change being considered as the time of presenting the demand, for either of the two modifications.

RECOMMENDATION No. 24a.*

Priority of International Calls over Internal Calls.

The International Consultative Committee—

Considering :—

That the International Regulation providing that international calls should have priority only over private internal calls of the same category, is insufficient to guarantee quick traffic for connections with countries where internal urgent calls are allowed, it being understood that ordinary international calls having been given priority on the internal circuits of the country of origin, may be appreciably delayed at the terminal exchange of the country of destination if urgent calls are in preparation at this exchange.

That, for setting up an international call the international circuit is always the controlling circuit and that the communication should be established immediately its turn arrives on this international circuit.

That certain Administrations, who do not allow urgent calls in their internal service, actually give priority to all incoming international calls over all internal calls and do not get reciprocal treatment.

Considering, however :—

That possibly an urgent internal private call necessitates the use of a more important internal circuit (from the point of view of length) than the international circuit used for the international call in question.

Unanimously advises :—

That international calls, at least those using an international circuit between two terminal exchanges at a crow-fly distance equal to or greater than 600 kms, should have priority over ordinary or urgent private internal calls in the terminal countries.

RECOMMENDATION No. 25.†

Method of Establishing Calls with Préavis or Avis d'Appel.

The International Consultative Committee—

Considering :—

That the International Regulation (Brussels Revision, 1928) does not contain sufficient detailed information concerning the establishment of calls with préavis or avis d'appel.

That it would be advisable in the public interest to give increased facilities for préavis calls, especially on the long distance international service.

* This recommendation should be included between Recommendations 24 and 25 on p. 598 of the *Livre Jaune* (English Edition, p. 356).

† This recommendation replaces Recommendation No. 25 on pp. 598-605 of the *Livre Jaune* (English Edition, pp. 356-360).

That while telegrams could replace préavis calls and are more economical on long distance calls, the avis d'appel is of public utility in frontier communications and in districts where the telephone network is not highly developed.

Unanimously advises :—

1. That Section N of Article 72 of the International Regulation (Brussels Revision, 1928) should be revised and completed as described later, the arrangements for préavis and avis d'appel being kept separate for simplicity under the new arrangements outlined later.

SECTION N.

I.—Calls with Avis d'Appel.

§ 1.—(1) The request for a call can be accompanied by avis d'appel.

(2) An avis d'appel has for object the calling of a person or somebody living in the same house in order to answer a call at a public call office.

(3) Avis d'appel are set up by special arrangement between the Administrations concerned.

§ 2.—(1) An avis d'appel is charged at one-third of the charge applicable to an ordinary call of three minutes made during the same period as the call requested by the avis d'appel, with a minimum charge of 50 centimes (0.50 fr.).

(2) If an avis d'appel does not result in the establishment of a telephone call the charge will be one-third of the rate applicable to an ordinary call of three minutes' duration taken during the chargeable period in which the avis d'appel has been transmitted.

(3) Charges for avis d'appel are divided between the Administrations concerned in the same proportions as the charges for ordinary calls.

§ 3. An avis d'appel only gives the following information :—

(1) The name of the caller, and, if necessary, his telephone number.

(2) The name of the called party and, if necessary, his substitute and their full address.

(3) If necessary, the time after which the request for the call should be cancelled (R.I. Section L, paragraph 8) or the period during which the call must not be made.

This information is transmitted as quickly as possible from one exchange to the other* and is prefixed by the words " Avis d'appel " † ; the exchange of destination records them on forms for delivery to the called party.

The avis d'appel are delivered in the same manner as telegrams.

When the called party lives outside the free delivery area for telegrams the avis d'appel will be surcharged an amount equal to that applying to an international express telegram in accordance with the publications of the International Bureau of the Telegraph Union. This surcharge is always charged to the caller : it forms part of the international accounts and is handed over to the Administration of the exchange of destination.

If the caller intimates, when originating his call with avis d'appel, that the called person lives outside the free delivery area and that the caller is paying the express fee, the transmission of the avis d'appel is preceded by the words " exprès payé."

When the caller does not possess any information as to the manner in which the avis d'appel is to be delivered, he is informed by the originating exchange that he may be charged a fee for expressing his avis d'appel. The caller is also informed that although the Administration will do all in its power to

* The same applies to all other service information relating to avis d'appel.

† If necessary the words " avis d'appel, exprès payé." . (*See* following paragraphs.)

make timely delivery of the avis d'appel, it cannot undertake any responsibility for this if the called party lives outside the free delivery area for telegrams.

When an exchange receives for distribution an avis d'appel which is not marked " exprès payé," and addressed to a party living outside the free delivery area, the exchange of origin is advised of this. If the caller refuses to pay the surcharge the call is cancelled, but the special charge for the avis d'appel is made.

The subscriber originating a call with avis d'appel may, if he has not been advised by his exchange to take the call, modify the particulars of his demand without however being able to change the terminal network—or to specify that the call be not established during a definite period or to advise that the demand be passed after a definite time. This facility is free of charge except in the case where the modification requires a second message to be sent. In this case, the special charge for avis d'appel and, if necessary, the messenger surcharge, are doubled.

§ 4. Calls with avis d'appel are subject to all the rules of international telephone communication, with the following reservations :—

§ 5. Calls with avis d'appel are only established in their order when the controlling exchange (terminal exchange, originating end, in case of direct calls, transit exchange in the case of transit calls) has been informed that the called party is ready to receive the call.

§ 6. To establish a call with avis d'appel the procedure is as follows :—

(*a*) The controlling operator in transmitting the avis d'appel must give the approximate time at which the call should be established.

(*b*) As soon as the called party (or his substitute) appears at the call office or announces that he is ready to receive the call at a subscriber's station which he indicates, the terminal exchange immediately advises the controlling exchange. The latter establishes the call in its turn.*

(*c*) When the terminal exchange is informed that the called party (or his substitute) can be reached at a public call office or at a subscriber's station of another network, the caller is informed of this and the original call is cancelled. If the caller asks for a call in another network it is treated as a new application.

If the terminal exchange is informed that the called party (or his substitute) cannot or does not wish to receive the call, the caller is informed at once and the call is cancelled.

(*d*) If the terminal exchange is informed that the called party (or his substitute) cannot answer the call at the approximate time arranged, the caller should be immediately advised. As soon as the terminal exchange can give the time from which the called party (or his substitute) will be able to receive the call, the caller will be notified of this.

If at the time at which the called party is ready to receive the call the turn for setting up this call has not yet arrived, the call shall retain its normal sequence.

If its turn has already passed, the request shall take its place in the normal sequence of its category, following calls already in preparation at that time.

§ 7. If, after calling at the public call office, the called party (or his substitute) makes known before the call is established (*see* § 10) that he can await the call no longer, the calling party is advised and the demand for the call is cancelled.

§ 8. An application for a call with avis d'appel is valid until the closing hour of the exchanges concerned. If all the exchanges in question give a twenty-four hours' service, applications for calls with avis d'appel received before 10 p.m. are cancelled at midnight, except in cases where the exchanges have been informed that a call can take place between midnight and 8 a.m. ; applications for calls with avis d'appel received between 10 p.m. and midnight are cancelled the next morning at 8 o'clock.

§ 9. If for any reason an avis d'appel cannot be delivered, the caller is informed thereof and the demand for the call cancelled.

§ 10. At the beginning of the call which immediately precedes the call with avis d'appel, the exchange of origin and of destination will inform the caller and the called party that the call with avis d'appel will be established in a few minutes, and will ask the persons concerned to keep themselves in readiness to receive the call (warning call).

* When a person is to receive a call at a subscriber's station, the arrangement relating to préavis will apply.

§ 11. The special charges appertaining to avis d'appel and also to express delivery are not demanded in the following two cases :—

(*a*) When, through defective service, the transmission of the avis d'appel has not been effected.

(*b*) When, after the receipt of an avis d'appel, the call cannot take place through faults happening on the line or in the installation.

If the caller cancels his application for a call with avis d'appel after transmission of the avis d'appel has begun he will be charged with the avis d'appel charge; the terminal exchange is informed of the cancellation. This cancellation is notified to the called party if present at the public call office, or if he calls there later. If the caller wishes the called party to be informed of the cancellation at his house, a further charge corresponding to that for the avis d'appel is applied, possibly with an addition of an express surcharge.

If, before the departure of the messenger taking the avis d'appel with the extra fee " exprés payé," the terminal exchange is informed of the cancellation of the call, the express charge will not be made.

II.—Calls with Préavis.

§ 1.—(1) An application for a call can be accompanied by préavis.

(2) The object of préavis is generally to advise the subscriber's station that the caller wishes to speak to a certain person or to an indicated supplementary station.

However a préavis may be simply to advise the main subscriber that a call has been originated for his address.

(3) The caller is allowed to ask for a substitute in case the person he wishes to speak to is absent. If he does not name a substitute he has the privilege of asking for a second station where the wanted person may be found.

(4) The préavis are accepted by special arrangements between the Administrations concerned.

§ 2.—(1) A préavis is subjected to a charge of one-third of the ordinary rate applied to the normal three minutes' conversation, held for the same chargeable period as the conversation with préavis, with a minimum charge of 50 centimes (0.50 fr.).

(For occasional fixed time calls with préavis see § 3, Recommendation No. 17.)

(2) If a préavis is not followed by a call it is subjected to a charge of one-third of that applicable to a normal conversation of three minutes, held over the chargeable period during which the préavis was transmitted.

(3) The charges for préavis are divided between the respective Administrations in the same proportions as charges for calls.

§ 3.—(1) A préavis contains only the following information :—

(1) The caller's name and, if necessary, his telephone number;

(2) The proper designation of the called party, and, if necessary, his substitute or the supplementary station required;

(3) If necessary, the hour after which the demand for the call is to be cancelled (R.I. Section L, §8) or the period during which the call should not be made.

(2) This information should be sent as soon as possible from exchange to exchange* through to the terminal exchange, and is preceded by the word " préavis " : however, the caller's name or number, or both, will only be transmitted at the caller's request.

The caller, originating a préavis, may, if he has not been advised by his exchange to take the call, modify the particulars of his demand—without, however, being able to change the terminal network—

* This applies to all service information relating to préavis.

or to specify that the call be not established during a definite period, or to advise that the demand be passed after a definite time. This facility is free of charge.

§ 4. Calls which take place as the result of the préavis are subject to the international telephone regulations, subject to the following comments :—

§ 5. Calls with préavis are established in their proper sequence only if the controlling exchange (terminal exchange—originating end—in case of direct calls ; transit exchange in case of transit calls), has been informed that the called party is ready to receive the call.

§ 6. To establish a call with préavis, the procedure is as follows :—

(*a*) The controlling operator when transmitting the préavis to the terminal exchange must give the approximate time from which the call can be established.

(*b*) As soon as it has received the préavis, the terminal exchange should inquire whether the called party is ready to accept the call, and should at the same time state the approximate time at which the call will be made.

(*c*) If, on receipt of the préavis, the called station declares that he is ready to answer the call, the terminal exchange should advise the controlling exchange immediately ; the controlling exchange will then establish the call in its proper sequence.

(*d*) If the terminal exchange is informed that the called person can be found at a different station of the same local network, the call is put through as if the application had been for that particular station.

If the terminal exchange is informed that the called person can be found at a certain station of another network, the caller is advised and the application for the original call is cancelled unless the caller decides to accept the call with the original station in spite of the absence of the called party. If the caller applies for a call to the other network for the desired person this is treated as a new application.

If the terminal exchange is informed that the called party or supplementary station asked for cannot or does not wish to receive the call, the caller is notified immediately and the application for the call cancelled, unless the caller wishes to accept the call to the station indicated, in spite of the called party being absent.

(*e*) If the called station intimates that the person required cannot receive the call at the approximate time arranged for its establishment, this information is sent to the caller immediately. Further, if the called station at the request of the terminal exchange has been able to give the time from which the required person can receive the call, the information is to be sent to the caller immediately.

If no information can be given as to the time when the called party can be reached the terminal exchange should inquire at least once every hour (night service excepted) as to the possible time of return of the required person. As soon as the terminal exchange has received the necessary information the caller is informed immediately.

(*f*) If at the time the called party is ready to answer the call, its turn has not been reached, the call will keep its normal sequence.

If its turn has been passed, the call will follow according to its category at the end of the calls in preparation at that time.

§ 7. If the called party, having declared his readiness to answer the call, intimates before receipt of the warning call (*see* § 10) that he can no longer wait for the call or that the call must be adjourned, the procedure will be as indicated in § 6 (*d*), last paragraph, or 6 (*e*).

§ 8. An application for a call with préavis is valid until the closing times of the exchanges concerned. If the exchanges in question give a twenty-four hour service, applications for calls with préavis received before 10 p.m. are cancelled at midnight unless the exchanges have been informed that the conversation can take place between midnight and 8 a.m. ; applications for calls with préavis received between 10 p.m. and midnight are cancelled the next morning at 8 o'clock.

§ 9. In case of no reply at the time of transmitting the préavis to the called station another attempt should be made at the end of a few minutes ; if this is unanswered a third call should be made half an hour after the first. If this last attempt fails, the caller should be informed. If the caller does not then cancel his call the latter will remain valid for the period specified in § 8 ; during these delay periods the terminal exchange calls the required station repeatedly. When a reply is obtained the regulations given in § 6 are applicable.

§ 10. From the beginning of the call which immediately precedes the call with préavis the exchanges of origin and destination advise the calling and called stations respectively that the call with préavis can be established in a few minutes, and that the persons interested should stand by to receive the call. If at this time, or even at the moment of the actual call, the called station is unable to accept the call because the called party is not immediately available, the application for the call is cancelled, the caller

is informed, and the préavis rate only is charged. At the final call the terminal exchange should repeat to the called party his name and number.

If, at the time of the preliminary warning call, the called station declares its readiness to accept the call, the lines of the subscribers concerned remain connected respectively to the originating exchange and to the terminal exchange (warning call); the call is established in the usual manner, and is charged as if it were a call without préavis. (R.I., Section L, §§ 2 and 3.)

§ 11. The special charge for préavis is not applicable to the following two cases :—

(*a*) When, through defective service, the transmission of the préavis has not been effected.

(*b*) When, after the receipt of a préavis, the call does not take place through faults occurring on the line or in the installation.

If the caller cancels his application for a call with préavis, after the transmission of the préavis has been commenced, the préavis charge is applied. In this case the terminal exchange is informed of the cancellation, and the latter advises the main called station.

§ 12. In the case of no reply or refusal of the calling or called party, the additional charge for a préavis only is made (*see* Recommendation 54).

RECOMMENDATION No. 26.*

Bourse Calls.

The International Consultative Committee—

Considering :—

That § 10 of Section L of Article 72 of the International Regulation (Brussels Revision, 1928) concerning conversations originating from, or destined for **Bourses** (commercial, financial, etc.) should be clearly specified.

That it is necessary to treat separately the case where the **Bourse** contains public call offices accessible to all brokers and served by the Telephone Administration,

Unanimously advises :—

That the arrangements indicated in the following proposed regulation should be applied in this case.

Considering, on the other hand :—

That **Bourses** having public call offices accessible to all brokers, and not served by the Telephone Administration (**Bourses** with private exchanges), should be treated as subscribers,

Unanimously advises :—

1. That calls originating from, or destined for, such **Bourses** should be subject to the ordinary regulations of the international telephone service.

2. That the charge period for these conversations commences from the moment when the private exchange has replied (International Regulations, Section L, § 2-5).

3. That persons who request calls for **Bourses** be advised to include a préavis with their demands.

Considering finally :—

That the special arrangements provided in the following regulations constitute a breach in the regulations of the international telephone service, and that it is desirable to restrict, as much as possible, the number of cases of such breach,

* This recommendation replaces Recommendation No. 26 on pp. 606 to 609 of the *Livre Jaune* (English Edition, pp. 360-362).

Unanimously advises :—

That, in all institutions similar to **Bourses** (fairs, periodical exhibitions, etc.) the telephone installation should, as far as possible, be a private exchange.

The International Consultative Committee—

Considering :—

That it is desirable in future to standardise the **Bourse** exchanges,

Unanimously advises :—

That the C.C.I. recommendations relating to new **Bourse** exchange installations with regard to the exploitation of international circuits should be applied ("Livre Jaune," Compte Rendu—Plenary Meeting, Brussels, 1930 : Transmission Questions—Long Distance Central Offices).

Proposed Regulations for Calls originating from or destined to Bourses.

§ 1.—(1) The arrangements below apply to calls originating from or destined for public call offices in a **Bourse,** accessible to all the brokers and operated by the Telephone Administration.

All these call offices and the switch boards which serve them, if such exist, constitute what is called a **Bourse-exchange** ("**bureau-bourse**").

Calls originating from, or destined for, public call offices in a **Bourse,** accessible to all brokers, but not operated by the Telephone Administration, are subject to the general regulations of the international telephone service.

(2) Administrations concerned should communicate the official names of the **Bourses** having a "**bureau-bourse,**" and if they think necessary the days and the times during which these "**bureau-bourses**" are in use.

§ 2.—(1) For a request for a call originating at, or destined for, a "**bureau-bourse,**" the name of the **Bourse** and the name of the broker, calling or called, should be given.

Examples :—

(*a*) Amsterdam commercial **Bourse**—P. Jansen requests Paris Littré 24-30.

(*b*) Paris Littré 18-93 requests Amsterdam commercial **Bourse** Dunlop & Co.

(*c*) Amsterdam commercial **Bourse**—P. Jansen requests Paris financial **Bourse,** Lebrun, Banque Nationale Crédit.

Requests for calls destined for a "**bureau-bourse**" cannot be accompanied by a préavis or avis d'appel.

(2) The transmission of a request originating from a "**bureau-bourse**" conforms to the regulations (International Regulations, Art. 72 Section O, § 2 (1) and (4), but should include, as well as the ordinary indications, the name of the originating **Bourse.**

(3) Requests destined for a "**bureau-bourse**" during the operating times of this exchange, should be transmitted as rapidly as possible to the "**bureau-bourse.**"

Outside this period the transmission should be made according to agreement between the exchanges concerned.

(4) After the receipt of a request the receiving "**bureau-bourse**" should ascertain (several times if necessary) if the broker called is present and should advise him that he has been called (**avis préalable**—warning call). If this person accepts the call he should be advised definitely when his turn arrives (**avis définitif**).

If the warning call has not reached the required broker after a reasonable time, or if he does not accept the call, the controlling exchange should be informed.

In the first case the establishment of the call should be put back; in the second case the request for a call should be cancelled.

§ 3.—(1) Before the beginning of the conversation preceding that with the "**bureau-bourse**" the toll exchange should advise the "**bureau-bourse**" that the call is about to be established. The "**bureau-bourse**" should advise the broker, calling or called, as quickly as possible that his turn is about to arrive, and should indicate to him the call office to be used for his conversation.

(2) Before receiving the final advice (**avis définitif**) the broker can ask for the call to be established with another station of the same local network.

§ 4.—(1) The charge for the conversation should be made from the moment that the call is given to the broker.

However, if the preceding conversation has lasted less than three minutes and if the broker is not present to take his call at the expiration of these three minutes, the charge only begins at the end of these three minutes.

(2) If the broker does not arrive to time or does not appear at all, the call will be held for him during three minutes. A caller, however, may request that a call be held during a maximum period of six minutes.

§ 5.—(1) Calls destined for a "**bureau-bourse**" are liable to the ordinary fee, which can, by arrangement between the Administrations concerned, be increased by a surcharge fixed at one-third of the unit charge.

(2) This surcharge should be made for each request transmitted to a "**bureau-bourse**"; it forms part of the international accounts. In cases where the call is refused at the time of the warning call, the surcharge should then be levied.

(3) When, through a fault in the telephone service, the conversation cannot take place, the surcharge should not be levied.

(4) In cases where the call is refused at the time it is definitely announced, the rate for one minute of an ordinary call during the period of heavy traffic is applied only to "**bourse**" calls for which the originating country does not apply the additional rate applicable to "**bourse**" calls.

RECOMMENDATION No. 37.*

Operating Rules for International Transit Traffic.

The International Consultative Committee—

Considering:—

The difficulties which are encountered when using an intermediate exchange for transit calls,

Unanimously advises:—

1. That it is desirable to have direct circuits across transit countries in all cases where traffic justifies this.

2. That, failing these permanent direct circuits, it is advantageous, if circumstances are favourable, to allocate circuits at definite times so as to allow direct connections temporarily, according to the needs of the traffic.

* This recommendation replaces Recommendation No. 37 on pp. 621 and 622 of the *Livre Jaune* (English Edition, pp. 369 and 370).

Considering, on the other hand:—

That when it will not be possible to set up permanent direct circuits or temporary connections, it is desirable to standardise, as far as possible, the methods of operation in transit exchanges,

Unanimously advises:—

That it is desirable that the following rules for operation should be adopted for transit traffic in those cases where the connection passes through one transit exchange:—

(*a*) It is necessary for the transit exchange to control the call—that is to say, it will direct the preparation and the establishment of the circuit.

(*b*) Demands for calls should be transmitted as quickly as possible to the transit exchange. However, in order to avoid congestion at the control position of the transit exchange, it is desirable for each terminal exchange not to transmit to this control position too many demands for the same incoming terminal exchange. Consequently, the control operator at the transit exchange has the right to limit, if necessary, the number of demands simultaneously transmitted, the transmission of each demand can then be followed by the simple indication of the number of demands on hand.

Service advices of préavis or avis d'appel shall be transmitted in priority, independently of the demands for calls.

(*c*) After a transit conversation the terminal exchanges may directly pass other calls, even if the demands corresponding to these latter have not been transmitted to the transit exchange, the direct connection remaining established between the two terminal exchanges as long as the transit exchange considers it advisable, providing that there are no calls of a higher class waiting at the transit exchange (except for urgent internal private calls on hand at the transit exchange, where the international transit calls use an international circuit connecting two terminal exchanges whose crow-fly distance is equal to or greater than 600 km).

(*d*) The tickets for demands for transit calls of the same order in both directions shall be arranged on the same operator's position (controlling position); they shall take their turn amongst the other demands which are waiting at this position, according to their class and the time received by the transit exchange.

(*e*) The first transit call established in the same series is necessarily the oldest call of the highest class that is waiting on the controlling position, whatever has been the direction of the preceding call established between the two terminal exchanges and the transit exchange. Other transit calls of the series will then follow alternatively. The transit exchange will recommence alternation on the two circuits after the connection has been broken down.

(*f*) Before the commencement of the last but one call which has to be passed between the transit exchange and the two terminal exchanges, the two corresponding positions at the transit exchange shall advise the two other exchanges to prepare the transit connection. The terminal exchanges shall proceed then to warn the subscribers. If one of the subscribers does not reply, the transit exchange should be advised of this before the commencement of the last call preceding the transit connection, in order to avoid taking these two international circuits into use unnecessarily, and, should the case arise, to permit the preparation of the following transit connection.

(*g*) Circuits of the internal network and subscribers' lines should be available to the terminal exchanges in order to establish, without delay, transit calls when their turn arrives.

(*h*) In the case of disagreement between the terminal exchange on the caller's side, and the transit exchange concerning the duration of the calls, the opinion of the transit exchange shall prevail.

Note.—In the case where a connection uses more than two international circuits the Administrations and Operating Companies concerned will agree upon the controlling exchange.

RECOMMENDATION No. 39.*

Systems of Spelling and Phrases to be used for the Operation of International Circuits.

1. System of Spelling.

The International Consultative Committee—

Considering:—

That it is necessary, in order to transmit words which might be difficult to hear, to have an international system of spelling.

That the systems of spelling in force in the following countries: Germany, Austria, Belgium, France, Great Britain, Hungary, Norway, Holland, Sweden, German-Switzerland, French-Switzerland, Italian-Switzerland, Czecho-Slovakia, are not very similar.

That the Washington Radio Conference, 1927, has adopted a system of spelling for the transmission of radio telephony, but that certain guide words indicated in this system are not convenient, either because they are rarely used in ordinary speech or because they are not desirable from the phonetic point of view.

That the C.C.I. Telegraphs has decided to adopt for telegrams to be telephoned the same spelling system as the C.C.I. Telephones.

Unanimously advises:—

That from 1st September, 1931, this system should be applied to the international telephone service.†

Letters	Words to be used for Spelling.	Letters	Words to be used for Spelling.
A	Amsterdam.	N	New York.
B	Berlin	O	Oslo.
C	Casablanca.	P	Paris.
D	Danmark.	Q	Quebec.
E	Edison.	R	Roma.
F	Florida.	S	Santiago.
G	Gallipoli.	T	Tripoli.
H	Havana.	U	Upsala.
I	Italia.	V	Valencia.
J	Jerusalem	W	Washington.
K	Kilogramme.	X	Xantippe.
L	Liverpool.	Y	Yokohama.
M	Madagascar.	Z	Zurich.

2. List of Principal Phrases to be used for the Operation of International Circuits.

The International Consultative Committee—

Considering:—

§ 10 of Section O of the International Regulations (Revision of Brussels, 1928),

Considering, on the other hand:—

That it is necessary to reduce, as far as possible, loss of time and false operations due to the different languages employed in the various countries,

Advises:—

1. That Administrations should prescribe for the operators attending international circuits, for the operation of these circuits, phrases specified by the International Consultative Committee and published

* This recommendation replaces Recommendation No. 39 on pp. 623 and 624 of the *Livre Jaune* (English Edition, pp. 370 and 371).

† It is desirable that the International Bureau of the Telegraph Union, on the occasion of the next telegraph and radiotelegraph conferences in Madrid, 1932, should bring to the notice of the Administrations and Operating Companies this system of spelling which has been established after extensive laboratory and field experience.

in the form of a small pamphlet entitled " List of the most Common Phrases used in International Telephone Service."

2. That in connections between countries which do not use either the German, English or French language, the Administrations should prescribe for use the translation of these phrases into the language employed by common agreement on these connections.

D.—RATES AND TARIFFS.

RECOMMENDATION No. 45a.*

Rates for Calls using a Radiotelephone Circuit.

The International Consultative Committee—

Unanimously advises :—

1. That it is desirable for each European Country to set up only one rate zone for each connection over a radiotelephone circuit.

2. That the terminal charge and the transit charge overland be fixed by agreement between the Administrations and Operating Companies concerned.

However, with regard to the overland route crossing several transit countries, the sum of the terminal charge (levied by the originating or terminating country) and the transit charge or charges should be, in principle, the same for the same overland route between the terminal country and the radio transmitting station.

For example, the total charges for the overland route London—Germany are the same for a call Germany—Australia and for a call Germany—U.S.A., both using London as the radio transmitting station.

RECOMMENDATION No. 51a.†

Radio Broadcast Transmissions : Conditions of Acceptance and Tariffs.

The International Consultative Committee—

Considering :—

That sufficient experience in relaying radio-broadcast programmes has not yet been acquired to lay down definite regulations with regard to broadcast transmissions, and that the demands for the use of circuits for this purpose should still be considered by the Central Administrations or the " Central Departments " which act for the Administrations and Operating Companies on this subject.

Considering, further :—

That it is advisable, particularly for multiple relaying of broadcast programmes, to simplify, as far as possible, the procedure to be followed.

Unanimously advises :—

That the following regulations be provisionally applied to radio-broadcast transmissions :—

1. **Demands for use of circuits.**

The demand for circuits for radio-broadcast transmissions should be addressed by the Broadcasting Organisation transmitting the programme to the " Central Department " of its country.

* This recommendation should be included between Recommendations No. 45 and No. 46 on p. 630 of the *Livre Jaune* (English Edition, p. 374).

† This recommendation should be included between Recommendations No. 51 and No. 52 on p. 634 of the *Livre Jaune* (English Edition, p. 376).

The list of these Central Departments in the different countries from whom the Broadcasting Companies obtain the use of circuits (list containing names, postal address and telegraphic address of the various Departments) should be sent by the Secretary of the C.C.I. to Administrations and Operating Companies belonging to the C.C.I., who will send this list to the Broadcasting Companies in the respective countries.

The demands for circuits for radio-broadcast transmissions should always be submitted as soon as possible and, in all cases, generally at least 10 days' notice should be given. These demands will be satisfied if there is no inconvenience to the general telephone service and if the technical conditions will permit.

In exceptional or particularly simple cases, this period may be reduced, Administrations and Operating Companies endeavouring to grant this request without, however, giving any guarantee on this point.

When rather important modifications to lines and equipment are required for the transmission, the minimum notice should be 15 days.

In the case of intercontinental radio-broadcast transmissions at least 15 days is, in general, required.

For each transmission of radio-broadcast programmes, of interest to radio receiving stations in one country only, the Broadcasting Company which owns the broadcasting station or stations receiving the programme, should confirm, to the Central Department in its country, the request for the necessary circuits already submitted by the Broadcasting Company controlling the transmission of the programme. This confirmation should be accompanied by an agreement to pay the whole of the tax covering the use of the circuits.

For each transmission of radio-broadcast programmes of interest to radio receiving stations in several countries, the procedure should be as follows :—

(*a*) The list of broadcasting stations which are to receive the programme and of the exchange to which the microphone is connected, is sent by the Broadcasting Company transmitting the programme to each of the other interested Broadcasting Companies; each Broadcasting Company should transmit this list to the Central Department of its country, after having made any additions or modifications considered necessary. This list should include all the conversation circuits requested and, if necessary, all the reserve circuits required.

(*b*) The Central Departments should appoint an " Official Director " for this transmission. The Official Director should draw up, in agreement with all the Central Departments, a sketch showing the circuits to be used, including the conversation circuits and reserve circuits in the form shown below.

This sketch should include also the special repeater stations to which the Broadcasting Companies may communicate if, during the transmission, there should arise any unforeseen incident which requires immediate attention.

This Official Director should send (as soon as possible and at the latest three days after the receipt of the list mentioned above) two copies of this sketch to each Central Department concerned, who should send a copy to the respective Broadcasting Company. The Official Director, instead of preparing a sketch, may communicate, by telegraph or telephone, with the Central Departments concerned, giving the circuits to be used and any special repeater stations referred to above.

(*c*) As soon as the Broadcasting Company, controlling one or more broadcasting stations receiving the programme, receives the necessary information concerning the circuits for which it has to pay, it should send to the Central Department of its country, within 24 hours, an agreement to pay the required charge for the use of the circuits.

In order to facilitate this procedure, the Broadcasting Companies should study in advance the cases of multiple relaying of programmes which are likely to arise frequently.

It is useful also for the International Bureau of the Telegraph Union to publish and keep up to date the chart of international telephone circuits in Europe specially established or set up for radio-broadcast transmission. (*See* Recommendation No 4a above.)

2.—Rates.

The radio-broadcast transmissions are subject to the following charges when they do not make use of circuits specially established for the transmission of music. (*See* Recommendation No. 51.)

(*a*) For the portion of the transmission during the period of heavy traffic; the charge for ordinary calls.

(*b*) For the portion during the period of light traffic.

In the case of a subscription transmission or a transmission whose duration (during the period of light traffic) is at least one hour; the charge equal to one-half (½) the charge for an ordinary call during the period of heavy traffic.

In all other cases the charge is three-fifths (⅗) of the charge for an ordinary call during the period of heavy traffic.

The charge for the use of a circuit is made out to the Broadcasting Company (State or Private) receiving the programme; it is due for the whole period during which the circuit is at the disposal of the Broadcasting Company, including the tests carried out by the Broadcasting Company before the particular radio-broadcast transmission takes place.

The equipment of the central exchanges should provide the operating personnel, who are responsible for determining the chargeable period for ordinary telephone calls, with the facility for determining in the same way (and with equal accuracy) the chargeable period of the radio-broadcast transmission.

Where the equipment is such that this facility is not given, the technical departments responsible for the establishment of the communication should come to an understanding with regard to :—

(1) The moment the circuit is placed at the disposal of the users (beginning of the chargeable period); and

(2) The moment the circuit is given over by the users (end of chargeable period).

If the transmission is relayed, from intermediate exchanges, to other broadcasting stations, it is considered, from the taxation point of view, as several distinct conversations: one between the originating exchange and the first intermediate broadcasting station, the others between the consecutive intermediate broadcasting stations, or between the last intermediate broadcasting station and the extreme broadcasting station.

The charge for one circuit is always indivisible, and should be paid wholly by one Broadcasting Company.

As, normally, reserve circuits are not provided, if the Broadcasting Company thinks it necessary to have at its disposal such reserve circuits for any particular transmission, these circuits will be subject to the same charge as if they served for the transmission during the whole period. The conversation circuits are subject to the same charge as the circuits used for the transmission.

When the use of a circuit for radio-broadcast transmission requires special maintenance or the addition of special equipment or re-adjustment of existing apparatus, the additional expense as a result thereof, as well as that due to the re-establishment of the circuit to normal conditions, should be borne by the Broadcasting Company paying for the use of the circuit.

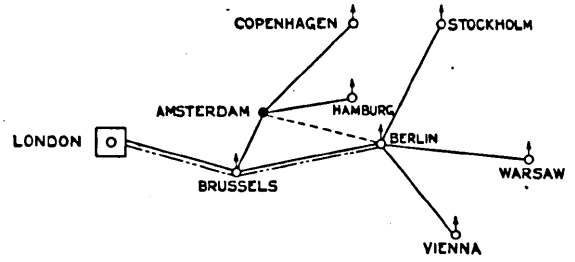
The Administrations and Operating Companies concerned should communicate the amount of these expenses to the Administration or Operating Company of the country in which the Broadcasting Company resides, this Administration or Operating Company holding these expenses to the credit of Administrations or Operating Companies concerned.

It is specially recommended that each radio-broadcast transmission should be included in the monthly accounts.

Example.—In the typical sketch below, Brussels, which broadcasts a programme from London, pays the charge for the circuit Brussels—London; if Berlin broadcasts a programme from London, as well as Stockholm, Warsaw and Vienna, the Broadcasting Company of Berlin pays the international charge for the circuit Berlin—Brussels, whilst the Broadcasting Companies of Stockholm, Warsaw and Vienna pay the international charges for the circuits Berlin—Stockholm, Berlin—Warsaw, Berlin—Vienna, respectively.

But as Amsterdam does not broadcast the programme the Broadcasting Companies of Hamburg and Copenhagen should agree beforehand as to whether the Broadcasting Company of Copenhagen will pay the charge for the circuit Brussels—Copenhagen, or merely for the circuit Amsterdam—Copenhagen.

Further, a previous arrangement should be made between the Broadcasting Companies concerned as to the payment for the conversation circuit and, if necessary, the reserve circuits.



CONVENTIONS

——— RELAYING CIRCUIT.
- - - - - - RESERVE CIRCUIT.
——·——·—— CONVERSATION CIRCUIT.
EXCHANGE TO WHICH THE MICROPHONE IS CONNECTED.
INTERMEDIATE STATION (OR BRANCH POINT) NOT RELAYING THE PROGRAMME.
BROADCASTING STATION WHICH RELAYS THE PROGRAMME.

Circuit.	Caller (*i.e.*, The Broadcasting Co. paying for the use of the circuit.)	Special repeater station for communication in case of unforeseen trouble on the circuit.
London-Brussels ...	Brussels.	
Brussels-Amsterdam ...	The Broadcasting Cos. of Hamburg and Copenhagen should come to an understanding as to who shall pay for the circuit Brussels-Amsterdam.	
Amsterdam-Copenhagen	Copenhagen.	
Amsterdam-Hamburg ...	Hamburg.	
Brussels-Berlin	Berlin.	
Amsterdam-Berlin ... (reserve).	The Broadcasting Cos. concerned should determine which company (Hamburg, Copenhagen or Berlin) will pay for the reserve circuit Amsterdam-Berlin.	
Berlin-Stockholm ...	Stockholm.	
Berlin-Warsaw	Warsaw.	
Berlin-Vienna	Vienna.	
London-Berlin ... ... (conversation).	Berlin.	

RECOMMENDATION No. 52.*

Picture Transmission between Correspondents over General Service Circuits (conditions relating to acceptance and tariffs).

The International Consultative Committee—

Considering:—

That most of the Administrations have little experience of picture transmission by means of instruments operated by Administrations or Companies,

Unanimously advises:—

That it is premature to fix the rates for picture transmission between exchanges.

Considering, on the other hand:—

That the experience of some Administrations with respect to picture transmission, carried out and maintained by the interested parties by means of their own instruments and over international telephone circuits provided by the Administrations, shows that these transmissions involve special expenses to the Administrations, but that these can be compensated for if it ensures the use of the circuits during periods of light traffic,

Unanimously advises:—

That the transmission of pictures effected directly between the interested parties should conform to the following rules:—

1. Conditions of Acceptance: They shall be allowed without limitation of time:—

(*a*) During periods of light traffic;

(*b*) During periods of heavy traffic, except during periods of maximum traffic (to be decided, when necessary, by agreement between the terminal exchanges concerned),

provided that:—either

(1) the circuits are available; or

(2) the waiting time for ordinary calls at the time stipulated for the transmission of pictures does not exceed, or does not appear likely to exceed by reason of this transmission, the following delays:—

15 minutes for circuits less than 500 km in length.
30 „ „ „ between 500 and 1 000 km in length.
45 „ „ „ exceeding 1 000 km in length.

2. Tariffs: Provisionally the following rates shall apply:—

(*a*) For that part of the transmission falling within the heavy traffic period: the ordinary telephone call rate.

(*b*) For that part of the transmission falling within the light traffic period:

(1) In the case of transmission by subscription or for a transmission, during the period of light traffic period, of at least an hour's duration, one-half the tax for an ordinary call during the heavy traffic period.

(2) In other cases, three-fifths of the rate for an ordinary call in the heavy traffic period.

The equipment of the central exchanges should provide the operating personnel, who are responsible for determining the chargeable period for ordinary telephone calls, with the facility for determining in the same way and with equal accuracy the chargeable period of the transmission.

Where the equipment is such that this facility is not given, the technical departments responsible for the establishment of the communication should come to an understanding with regard to:—

(1) The moment the circuit is placed at the disposal of the users (beginning of the chargeable period).

(2) The moment the circuits are given over by the users (end of chargeable period).

Note.—Transit Administrations and Operating Companies are advised to facilitate transmission tests requested by terminal Administration and Operating Companies, provided that the above rates be applied to these tests.

* This recommendation replaces Recommendation No. 52 on pp. 635 and 636 of the *Livre Jaune* (English Edition, pp. 376 and 377).

The International Consultative Committee—

Considering, finally ;

That cases may exist where picture transmission between two countries will be carried out by connecting, over a telephone circuit, an instrument belonging to and maintained by a user, to an instrument belonging to the Administration of another country and situated in an exchange in that country,

Unanimously advises :—

That, in these cases, the use of the international circuit for picture transmission be subjected to the same conditions and rates (with respect to the international circuit) as those above relating to two private instruments, the Administration operating the exchange instrument making a supplementary charge for its use, the amount of which is not to appear in the international accounts.

RECOMMENDATION No. 54.*

Refusal or no reply from the Calling or Called Subscriber.

The International Consultative Committee—

Considering :—

That the collection of a fee in case of refusal or a no reply on the part of the calling or called subscriber is justified by the occupied line time and the work of setting up the connection,

That, however, the calling subscriber cannot be held responsible for a no reply from the called subscriber,

That, nevertheless, the refusal of the called subscriber may serve as an indication to the calling subscriber,

That it is necessary to simplify, as much as possible, the application of tariffs,

Unanimously advises :—

1. That, in the case of a refusal from the calling or called subscriber as well as in the case of no reply from the caller, the charge for one minute's ordinary conversation, appropriate for the tariff period, during which the refusal or no reply occurred, shall be made.

2. That, for occasional fixed time calls, in the case of refusal from the calling or called subscriber, as well as in the case of no reply from the caller, when he is called by his exchange to take the call (final call), the tax, applicable to one minute of ordinary conversation for the tariff period, during which the refusal or no reply occurred, shall be made.

3. That for calls with préavis or avis d'appel and for "**Bourse**" calls, in case of refusal or no reply on the part of the calling or called subscriber, the surcharge applicable to a préavis or an avis d'appel shall be made.

RECOMMENDATION No. 56 (a).†

Rates for Calls during Two Tariff Periods.

The International Consultative Committee—

Considering :—

That it is reasonable to charge for calls by taking into account as far as possible the heavy and light traffic periods during which the conversation takes place,

* This recommendation replaces Recommendation No. 54 on pp. 637 and 638 of the *Livre Jaune* (English Edition, p. 378).

† This recommendation should be included between Recommendations No. 56 and No. 57 on p. 638 of the *Livre Jaune* (English Edition, p. 378).

Unanimously advises :—

(1) That a call taking place within both the light and heavy traffic periods should be taxed as follows :—

(*a*) If the duration is not greater than three minutes : The tax applicable to the period when conversation commenced should be made.

(*b*) If the duration exceeds three minutes : The first three minutes should be taxed in accordance with the rate applicable to the time of the commencement of the call, and the extra minutes in accordance with the rate for the time of the commencement of each of these minutes.

(2) That § 8 of Section L of the International Regulations (Revision of Brussels, 1928) should be replaced by the following text :—

" That a call taking place within both the light and heavy traffic periods should be taxed as follows :—

" (*a*) If the duration is not greater than three minutes : The tax, applied by the originating Administration or Operating Company to the heavy or light traffic period, according to which period the conversation commenced, should be made.

" (*b*) If the duration of conversation exceeds three minutes : The first three minutes should be taxed in accordance with the rate applied by the originating Administration or Operating Company, at the moment the conversation commenced, and the additional minutes, in accordance with the rate of this Administration or Operating Company at the time of commencement of each of these minutes."

E.—TRAFFIC STATISTICS.

RECOMMENDATION No. 60 (a).*

Publication of General Telephone Statistics by the International Bureau of the Telegraph Union.

The International Consultative Committee—

Unanimously advises :—

(1) That the International Bureau of the Telegraph Union should publish the General Telephone Statistics each year in the following form.

(2) That the new Table proposed by the C.C.I. should be submitted as soon as possible, by the International Bureau of the Telegraph Union, for the approbation of the Administrations and Operating Companies not belonging to the C.C.I., since it will be advisable to have the statistics for the year 1931, which will be published in 1932, in the following form.

(3) That Administrations and Operating Companies should send their information as soon as possible to the International Bureau of the Telegraph Union, so that the Statistics for any particular year be published at the latest by 1st August of the following year.

FORM OF TABLE FOR GENERAL TELEPHONE STATISTICS.

I.	Population	
II.	Area	
III.	Number of central exchanges in service (1) :—	
	1. Automatic exchanges	
	2. Semi-automatic exchanges	
	3. Manual exchanges	
	Total central exchanges	
IV.	Number of subscribers' lines in service (2) :—	
	1. Subscribers' lines directly connected to automatic exchanges	
	2. Subscribers' lines directly connected to semi-automatic exchanges	
	3. Subscribers' lines directly connected to manual exchanges	
	Total subscribers' lines	

* This recommendation should be included between Recommendations No. 60 and No. 61 on p. 643 of the *Livre Jaune* (English Edition, p. 381).

V. Number of stations in service (3) :—

1. Subscribers' stations (3) (including extensions and service stations) ... ...
2. Public stations (4) ... ...

Total stations ... ...

VI. Toll and international circuits in service :—

1. Total number of internal circuits (being the total of physical, phantom and carrier circuits ... ...
2. Total number of international circuits (being the total of physical, phantom and carrier circuits) ... ...
3. Total length in kilometres of bare wire circuits (internal and international) ...
   (*a*) Physical circuits ... ...
   (*b*) Phantom circuits ... ...
   (*c*) Carrier circuits ... ...
4. Total length in kilometres of aerial or underground cable circuits (internal and international) :—
   (*a*) Two wire physical circuits ... ...
   (*b*) Four-wire physical circuits ... ...
   (*c*) Phantom circuits (four-wire or two-wire) ... ...
5. Total length in kilometres of submarine circuits (internal and international) :—
   (*a*) Two-wire physical circuits ... ...
   (*b*) Four-wire physical circuits ... ...
   (*c*) Phantom circuits (two-wire or four-wire) ... ...
   (*d*) Carrier circuits ... ...

VII. Traffic :—

1. Local traffic :—
   (*a*) Number of chargeable calls (irrespective of duration) from subscribers' stations ... ...
   (*b*) Number of chargeable calls (irrespective of duration) from public stations ... ...

   Total local calls ... ...

2. Toll traffic :—
   (*a*) Total number of chargeable minutes of conversation :—
      (1) During the heavy traffic period ... ...
      (2) During the light traffic period ... ...

      Total ... ...

   (*b*) Number of chargeable calls (irrespective of duration) :—
      Ordinary ... ...
      Urgent ... ...
      Lightning ... ...
      By subscription ... ...
      With préavis ... ...
      With avis d'appel ... ...
      Occasional fixed time ... ...
      Radio-broadcast transmissions (6) ... ...

      Total ... ...

3. International traffic (outgoing, incoming and transit) :—
   (*a*) Total number of chargeable minutes of conversation :—
      (1) During the heavy traffic period ... ...
      (2) During the light traffic period ... ...

      Total ... ...

   (*b*) Number of chargeable calls (irrespective of duration) :—
      Ordinary ... ...
      Urgent ... ...
      Lightning ... ...
      By subscription ... ...
      With préavis ... ...
      With avis d'appel ... ...
      Occasional fixed time ... ...
      Radio-broadcast transmissions (6) ... ...

      Total ... ...

VIII. Total expenses in gold francs of the internal and international telephone service (including interest on capital and depreciation) ... ... Optional.

Total receipts in gold francs of the internal and international telephone service ... ...

EXPLANATORY NOTES.

1. A central telephone exchange is an automatic, semi-automatic or manual installation to which subscribers are connected and which is operated by an Administration or Telephone Operating Company.

2. Include in the number of subscribers' lines the lines of the service stations and public stations.

3. Do not include among subscribers' stations, private stations which cannot be connected with the general telephone network.

4. Include among the public stations all those telephones which have been placed at the disposal of the public by the Administration or Operating Company.

5. In the case where a submarine cable belongs to two Administrations or Operating Companies, only the length of the section belonging to the particular Administration or Company should be included.

6. Under internal toll traffic, each radio-broadcast transmission, which may be broadcast by one or several stations, is counted as one only.

Under international traffic, each country taking part in the radio-broadcast transmission, either with the transmitting station, with one or several receiving stations, or as a transit country, counts one unit.

If in the transit country, the transmission is connected to one or several receiving stations, this is nevertheless considered by this country as an international radio-broadcast transmission; it is not therefore mentioned in the internal traffic.

If a broadcast programme is transmitted at the same time for internal service and international service, it should be included as an internal transmission and as an international transmission.

If, during the period of the transmission, a change of the transmitting centre is made, this change is considered as an additional transmission from the statistical point of view.

RECOMMENDATION No. 63.*

Forecast of International Traffic. Lists of Circuits to be prepared.

The International Consultative Committee—

Considering:—

That in spite of the uncertainty of future traffic conditions in the course of successive years, traffic forecasts are very useful in order to prepare in advance a programme of work extending over several years;

That the importance of the capital invested in international telephone cables and the time required for the construction and laying of new cables justify the preparation of advance programmes of work covering several years,

Unanimously advises:—

(1) That in order to facilitate an exchange of views between Administrations and Operating Companies concerning the creation of new international circuits, such exchanges of views as take place during plenary meetings of the C.C.I., but outside the regular conference work of the C.C.I., should be notified to the C.C.I. Secretariat in advance at the same time as traffic statistics, with lists of new international circuits estimated to be required by Administrations and Operating Companies (including new radio-telephone circuits, if this is convenient to the Administrations and Operating Companies).

(2) That it is recommended that Administrations and Operating Companies shall indicate in the column " Observations " on statistics of international traffic (Recommendation No. 60, " Livre Jaune " p. 642) explanations of any abnormal variations in the traffic data collected.

(3) That Administrations and Operating Companies interested are advised to use the form given herewith below in recording the information on circuits, the need for which is considered necessary.

* This text replaces Recommendation No. 63 on pp. 647 and 648 of the *Livre Jaune* (English Edition pp. 383 and 384).

LIST OF INTERNATIONAL CIRCUITS, THE PROVISION OF WHICH IS DEEMED NECESSARY BY:

(Name of Administration or Company)

Communication with..... (Give names of Countries in alphabetical order.)	Circuit designations.	Number of circuits in service on the route involved.	Name of Countries through which the route considered is passing.	Average daily number of minutes of conversation exchanged over all the circuits on the route under consideration.						Average % increase per annum observed during the last two years.	No. of circuits projected.			Is the Administration or Company who compiled this Table willing to guarantee a minimum revenue to transit countries for the projected circuits?
				1928		1929		1930						
				From 8 h to 19 h	From 19 h to 8 h	From 8 h to 19 h	From 19 h to 8 h	From 8 h to 19 h	From 19 h to 8 h		1931	1932	1933	
1.	2.	3.	4.	5.						6.	7.			8.

VI.—QUESTIONS CONCERNING PROTECTION OF LINES.

PART I.

PROTECTION OF TELEPHONE LINES AGAINST THE DISTURBING INFLUENCE OF HEAVY CURRENT OR HIGH TENSION ELECTRIC POWER INSTALLATIONS.

Guiding principles concerning measures to be taken in order to protect telephone lines against the disturbing influences of heavy-current or high-tension lines.

The International Consultative Committee—

Considering :—

That the 1926 edition of the "Guiding principles concerning measures to be taken in order to protect telephone lines against the disturbing influences of heavy-current or high-tension lines," is no longer up to date in view of numerous modifications made during subsequent Plenary Meetings of the C.C.I.

Considering :—

On the other hand, the Editing Committee of the Guiding Principles, appointed by the Plenary Meeting of Berlin, 1929, has prepared a new, revised and up-to-date version, that the new text has been compiled and examined with great care in collaboration with representatives of international electro-technical organisations concerned (International Railway Union, International Union of producers and distributors of electric energy, International Conference of large electric networks) and has been officially communicated to these organisations,

Unanimously advises :—

That, in the future, the new edition of the Guiding Principles of 1930 shall be used, replacing the old 1926 edition.

Apparatus for measuring noise voltage objectively.

The International Consultative Committee—

Considering :—

That it is necessary for practical purposes to have apparatus to measure noise voltage objectively and that such apparatus should be adopted for a fairly long period in all countries, even if it is only capable of giving approximate readings;

That numerous tests enable us to specify to-day the chief characteristics of such apparatus,

Unanimously advises :—

That noise voltage (defined in § 8 of Chapter III in the "Guiding principles concerning measures to be taken in order to protect lines against the disturbing influences of heavy-current or high-tension lines"—1930 edition) shall henceforward be objectively measured by means of the apparatus, the chief characteristics of which are specified in the Appendix below, and which comprises an amplifier, a filter and an instrument for measuring voltage.

Apparatus for measuring disturbing voltage objectively.

The International Consultative Committee—

Considering :—

That, according to the definition of the equivalent disturbing voltage of a power line, the weight to be given to each frequency is exactly the same as that given in the case of noise voltage,

Unanimously advises :—

That the apparatus intended for measuring disturbing voltage (or current) should comprise the same filter as the apparatus for measuring noise voltage, added to which, when necessary, should be a device representing the coupling between the power line and the telephone circuit.

APPENDIX.

I. CHIEF CHARACTERISTICS OF THE APPARATUS FOR MEASURING NOISE VOLTAGE OBJECTIVELY ON COMMERCIAL TELEPHONE CIRCUITS.

(a) Characteristic curve of the filter.

Table I gives under the heading "Weighting Factor" the relative values of the average disturbing effects of various frequencies, when the voltage at the terminals of the subscriber's receiver is the same for each frequency.

Each weighting factor is given as a relative value with reference to that for a frequency of 1050 p : s. For each relative value corresponding transmission units are given (népers and decibels).

The apparatus for measuring noise voltage objectively should have a filter, associated with an instrument for measuring voltage, the transmission characteristics of which should be such that, if an alternating voltage of given frequency is applied to the input terminals, the voltage at the terminals of the measuring instrument is proportional to the relative weighting factor of that frequency.

In the design of the above apparatus a certain tolerance in the filter characteristics is permitted on the values in Table I to the extent of the provisional limits given below. It is desirable, and will perhaps be possible, to reduce these tolerances later on if manufacturing conditions permit.

TOLERANCES.

Tolerance for maximum ordinate (1050 p : s) = ±50 p : s.

50 and 60 p : s	— ·	± 2	decibels	or 0.24	néper.
60 to 150 „	—	± 3	„	0.35	„
150 „ 400 „	—	± 2	„	0.24	„
400 „ 1800 „	—	± 1	„	0.12	„
1800 „ 3000 „	—	± 3	„	0.35	„
3000 „ 5000 „	—	± 5	„	0.58	„

(b) Voltage measuring instrument.

The voltage measuring instrument shall measure the effective value of the voltage at its terminals.

(c) Graduation of the measuring instrument.

This instrument shall be graduated in millivolts in such a manner that the scale readings shall be proportional to the voltage values at 800 p : s, applied to the input terminals of the apparatus as a whole.

(d) Input impedance of the apparatus.

The apparatus for measuring noise voltage objectively, being intended to work in shunt with a receiver, the impedance of which is some hundreds of ohms, should have an input impedance not lower than 10000 ohms.

(e) Method of operation.

The weighting factors given in Table I for the various frequencies have been chosen so that the apparatus gives a correct measure of the average noise effect observed by the subscriber, when the said

apparatus is shunted across the terminals of the receiver of the subscriber's set on his premises under normal working conditions.

When measuring the noise voltage at the end of a long distance circuit it is necessary to connect to its terminals an auxiliary device, designed to simulate the distortion introduced by the line and equipment, which under normal working conditions connect the long-distance line with the subscriber's receiver, including the subscriber's apparatus. This auxiliary device may be a circuit model, made up of artificial lines, representing those intermediary between the subscriber and the long-distance office and equivalents of all intermediary equipment therein, including the subscriber's set. The noise measuring set is then shunted across the terminals of the receiver of the subscriber's set. Instead of a circuit model a filter network may be used, so constructed that it faithfully reproduces the frequency characteristics of the lines and equipment involved between the long-distance line and the subscriber's set.

When measurements are made at the terminals of a telephone receiver and v is obtained as a reading on the instrument, the noise voltage V (defined in the "Guiding principles") is :—

$$V = v\sqrt{600/Z}.$$

Where Z is the impedance of the receiver at the predominant resonance frequency when disconnected from the set and placed with its ear cap on a table, covered with felt about 1 cm thick.

If, on the other hand, a network is used, which reproduces the transmission characteristic of the line and equipment intermediary between the toll line and the subscriber's telephone receiver, the latter being included, it is necessary first to assign an impedance value to the latter, as indicated in the preceding paragraph.

On the other hand, the whole noise measuring set may be calibrated so as to obtain the relation between the readings on the instrument and the values of V, obtained when measurements are made directly at the terminals of the receiver contained in the arrangement represented by the filter network. The instrument may be graduated so as to give direct readings of v, or, if so desired, of the noise voltage V.

II. CHIEF CHARACTERISTICS OF THE APPARATUS FOR MEASURING NOISE VOLTAGE OBJECTIVELY ON CIRCUITS USED FOR RADIO BROADCAST RELAYS.

The general instructions and the chief characteristics given above for noise measuring apparatus used on commercial telephone circuits apply to the apparatus which should be used on telephone circuits employed for radio broadcast relays, excepting that the data for the filter curve in this case should be based on the figures of Table II.

The weighting factors given to the various frequencies in Table II have been deduced from the curve of equal sound sensation of the ear (for a given average power) since, in effect, in broadcast relay transmissions the lines and apparatus are specially set up to give only very slight distortion, it is only necessary to take into account the properties of the ear.

The tolerances provisionally adopted for the curve, specified in Table II are :—

from 25 to 200 p : s $\pm$ 6 decibels or 0.7 néper.

from 200 to 6400 p : s $\pm$ 3 decibels or 0.35 néper.

from 6400 to 12800 p : s $\pm$ 6 decibels or 0.7 néper.

TABLE I.

Specification for the curve of the filter used in the noise voltage measuring apparatus for tests on a commercial telephone circuit. (*See* **Curve Fig. 1.**)

Abscissæ: Frequency.	Weighted Ordinates.		
	Relative values.	Decibels.	Népers.
16·7	0·00006	− 84·4	− 9·70
50	0·002	− 54	− 6·20
60	0·004	− 48	− 5·52
100	0·022	− 33	− 3·79
150	0·078	− 22·2	− 2·55
200	0·126	− 18	− 2·07
300	0·168	− 15·5	− 1·78
400	0·212	− 13·5	− 1·55
500	0·252	− 12	− 1·38
600	0·298	− 10·5	− 1·21
700	0·376	− 8·5	− 0·98
800	0·531	− 5·5	− 0·63
900	0·750	− 2·5	− 0·29
1 000	0·977	− 0·2	− 0·02
1 050	1·000	− 0·0	− 0·0
1 100	0·945	− 0·5	− 0·06
1 200	0·670	− 3·5	− 0·40
1 300	0·422	− 7·5	− 0·86
1 400	0·282	− 11	− 1·27
1 500	0·224	− 13	− 1·50
1 600	0·189	− 14·5	− 1·67
1 800	0·150	− 16·5	− 1·90
2 000	0·133	− 17·5	− 2·01
2 200	0·119	− 18·5	− 2·13
2 400	0·106	− 19·5	− 2·24
2 600	0·095	− 20·5	− 2·36
2 800	0·084	− 21·5	− 2·47
3 000	0·075	− 22·5	− 2·59
3 500	0·042	− 27·5	− 3·16
4 000	0·024	− 32·5	− 3·73
5 000	0·010	− 40	− 4·60

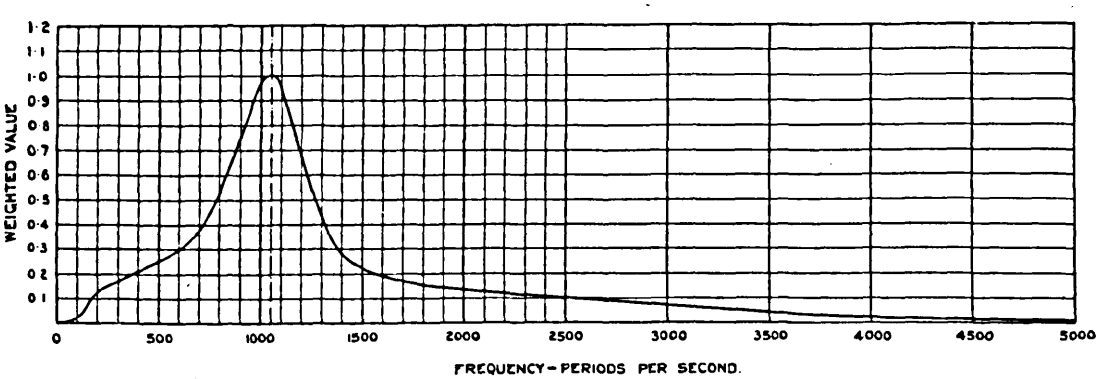


FIG. 1.

TABLE II.

Specification for the curve of the filter used in the noise voltage measuring apparatus for tests on a telephone circuit, used for relaying broadcast transmission.

(*See* **Curve Fig. 2.**)

Abscissæ : Frequency.	Weighted Ordinates.		
	Relative values.	Decibels.	Népers.
25	≤ 0·002	≤ − 54	≤ − 6·21
50	0·005	− 46	− 5·29
100	0·025	− 32	− 3·68
200	0·126	− 18	− 2·07
400	0·501	− 6	− 0·69
800	0·891	− 1	− 0·12
1 600	1·12	+ 1	+ 0·12
3 200	1·26	+ 2	+ 0·23
6 400	0·501	− 6	− 0·69
12 800	≤ 0·016	≤ − 16	≤ − 1·84

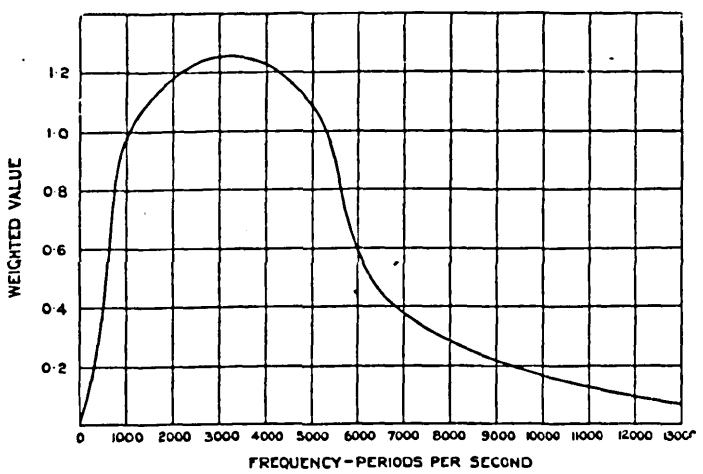


FIG. 2.

STUDY OF THE DISTURBING VOLTAGE OF DIRECT CURRENT INSTALLATIONS.

The International Consultative Committee—

Considering :—

That, according to the definition of the equivalent disturbing voltage of a power line, the weighting factor to be assigned to each frequency is exactly the same as for that applied in the definition of noise voltage.

That the apparatus used for measuring the disturbing voltage should therefore be similar to that used in noise voltage tests.

Unanimously advises :—

That the study of the permissible limits of the disturbing voltage of direct current installations should be continued, using a device provided with a filter identical to that used in noise voltage tests to which should be added, when necessary, a device representing the coupling between the traction line and the telephone line.

REDUCTION OF THE DISTURBING VOLTAGE OF RECTIFIERS.

The International Consultative Committee—

Considering :—

That it is possible to obtain a substantial reduction in the disturbing voltage of traction lines, supplied by rectifiers by the use of a choke coil, in conjunction with resonant shunts.

That, on the other hand, the Hungarian Administration has suggested the use of a device, comprising, in addition to the resonant shunts, a filter, replacing the choke coil.

That, in any case, the device is more onerous and is not perhaps sufficient to suppress all the frequencies,

Unanimously advises :—

That, so far as the reduction of the disturbing voltage of rectifier installations are concerned, devices comprising a choke coil in conjunction with resonant shunts are recommended for use.

That for six-phase rectifiers it seems desirable to design the characteristics of these shunts so as to reduce the disturbing voltage as far as is technically possible to at least one-tenth of the value it would attain if no resonant shunts were used.

DEFINITION AND MEASUREMENT OF THE DISTRIBUTED UNBALANCE OF A TELEPHONE LINE WITH RESPECT TO EARTH.

The International Consultative Committee—

Considering :—

That the study of the conception of the unbalance with respect to earth has proved that, in general, it is not possible to establish a direct relation between the value of the noise voltage and the results of an unbalance measurement at the end of a long circuit.

That, on the other hand, it is useful to adopt a simple conception, which makes it possible to ascertain approximately the condition of the circuits from the standpoint of their set-up and maintenance.

Unanimously advises :—

That, so far as long circuits are concerned, the definitions and methods of testing unbalance, prescribed in the " Guiding Principles," are sufficient for practical purposes.

DEFINITION AND MEASUREMENT OF THE LOCALISED UNBALANCE OF A TELEPHONE LINE WITH RESPECT TO EARTH.

The International Consultative Committee—

Considering :—

That, in the case of short circuits, in which the unbalances to earth, due to installation are so great as to render the line unbalance negligible, it is possible to define the magnitude of the unbalance in direct relation to the noise voltage.

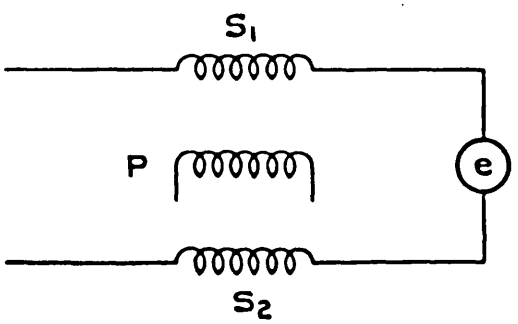
Unanimously advises :—

That, for this particular case, the following definition should be adopted :—

Given a circuit, at each end of which there is a telephone installation, and assuming equal voltages E, of telephone frequency, applied to each of its wires.

If the circuit is not perfectly balanced a voltage e will be observed at the terminals of the receiver of one of the installations. Conventionally, the unbalance of the circuit at that end and for the frequency used is expressed by the ratio e/E.

The measurement may be made in accordance with the schematic:



The transformer shown has three windings. The secondaries S_1 and S_2 have the same mutual inductance with respect to the primary P and have equal impedances, low compared to the impedance of the circuit.

USE OF ELECTROSTATIC FORMULÆ FOR CALCULATING THE INFLUENCE OF AN ALTERNATING CURRENT POWER LINE ON A TELEPHONE CIRCUIT.

The International Consultative Committee—

Considering:—

That special studies undertaken on this subject having shown that the effect of the distribution of the currents in the earth upon the determination of the capacity coefficients is absolutely negligible at commercial and telephonic frequencies.

Unanimously advises:—

That it is not necessary to modify the reasoning, in the "Guiding Principles," on the subject of computing the induction of an alternating current power line into a telephone circuit, the reasoning being based on electrostatic formulæ.

EFFECT OF TRANSPOSITIONS IN A POWER LINE.

The International Consultative Committee—

Considering:—

That the diminution of the disturbing effect of the residual components of the various harmonics of alternating voltages and currents, obtained by means of transpositions according to the methods described in the "Guiding Principles," depends on numerous factors, such as the wave form of the generator, the length of the line, the type and arrangement of transformers, etc. . . .

That, consequently, a theoretical study of this complex problem does not appear to lead to results of practical utility.

That, on the other hand, it appears, from studies made in the United States of America, that omitting the transposition at the point where two complete rotations (barrels) should coincide would tend to reduce the residual voltages and currents.

Unanimously advises:—

That there appears to be no inconvenience caused by omitting that transposition.

That, concerning the problem as a whole, it does not seem opportune to undertake new investigations of this subject.

EARTHING A TELEPHONE CIRCUIT IN A LONG-DISTANCE CABLE.

The International Consultative Committee—

Considering :—

That, in the present state of the art, cables are made with extremely low unbalances between the various circuits and earth, particularly so with respect to the circuits in the inside layers of the cable.

That these unbalances are sufficiently low if the circuits are not to be earthed;

That, furthermore, each earthing—even with apparent symmetry—involves a risk of bringing into play inductance and resistance unbalances for each circuit which is earthed.

That the dielectric strength between two circuits in a cable is ordinarily very much lower than that between the circuits and the lead sheath and, therefore, the earthing of certain circuits is liable to cause a risk of breakdown of the dielectric between the conductors when the cable is exposed to serious induction effects.

That, when the cable is subjected to an induced voltage of considerable magnitude, the presence of an earth allows currents to flow with an amplitude which in some cases exceeds the limit which may be permitted in order to maintain the good magnetic quality of the loading coils.

Unanimously advises :—

1. That it is recommended not to earth a circuit in a long-distance cable at any point.

2. That, as a general rule, it is recommended not to earth any point of an installation (telephone or telegraph), which is metallically connected to a long-distance cable circuit.

3. That, in all cases, where special reasons demand the earthing of an installation which is directly connected to the conductors of a cable, the following precautions should be taken :—

(*a*) The earthing should be done so as not to interfere with the balance of the circuits with respect to earth or neighbouring circuits.

(*b*) The breakdown voltage of all the remaining conductors of the cable with respect to the earthed circuit should be appreciably greater than the highest voltage which, by reason of the induction of neighbouring power lines, may be present between these conductors and the earthed circuit.

(*c*) When a telegraph installation is connected to a cable the prescriptions of the C.C.I. on the subject of co-existence of telegraphy and telephony on the same circuit should also be observed.

LINKING UP PUBLIC TELEPHONE SYSTEMS WITH TELEPHONES ASSOCIATED WITH POWER INSTALLATIONS.

The International Consultative Committee—

Considering :—

That distributors of electric energy require connections between circuits suspended on pole lines or in cables of the public telephone system and carrier frequency circuits superimposed on the high tension conductors or ordinary telephone circuits, suspended on the poles, carrying the high tension lines.

That, if such arrangements are allowed, every precaution should be taken to prevent dangers arising from any derangement of the coupling devices between the lines.

That experience in certain countries for over ten years has shown what precautions should be taken.

Unanimously advises :—

That from a technical standpoint it appears possible to permit these connections being made, provided the installations conform to the prescriptions given below.

These prescriptions are in two parts : one covers the case of telephone lines carried on the same pole as the high tension line ; the other applies to carrier circuits superimposed on high tension lines.

I. CONDITIONS TO BE FULFILLED IN CASES WHERE A TELEPHONE LINE, L_1, CARRIED ON THE POLES OR IN THE CABLES OF A PUBLIC TELEPHONE NETWORK, IS CONNECTED TO AN ORDINARY TELEPHONE LINE, L_2, SUSPENDED ON THE HIGH TENSION LINE POLES.

(*a*) The coupling devices between the two telephone lines L_1 and L_2 should conform to the best practices of the art.

(*b*) In the event of contact between the high tension conductors and the wires of line L_2 the possibility of high tension current entering the telephone line L_1 should be satisfactorily eliminated by the coupling device, which should, generally, be equipped with an insulating transformer, lightning protectors and fuses of sufficient capacity.

(*c*) In no case, even when the accidental contact above assumed occurs, should the voltage produced in line L_1 exceed 250 volts.

(*d*) All connections to earth, made on the coupling devices, should be carried out in accordance with the usual rules covering the earthing of high tension installations, imposed by each country.

(*e*) Regarding operating practice, the owner of the private lines should be responsible for the regular conditioning of the whole installation and for its maintenance in conformity with the rules outlined above.

II. CONDITIONS TO BE FULFILLED IN CASES WHERE A TELEPHONE LINE, L_1, CARRIED ON THE POLES OR IN THE CABLES OF A PUBLIC TELEPHONE NETWORK, IS CONNECTED TO A TELEPHONE LINE, L_3, OPERATED AS A CARRIER CIRCUIT, SUPERIMPOSED ON THE HIGH TENSION LINE.

(*a*) The coupling devices between the two telephone lines L_1 and L_3 should conform to the best practices of the art.

(*b*) In all cases, even when a breakdown occurs in the coupling device between the high tension line and the carrier circuit, the possibility of high tension reaching line L_1 should be rigorously guarded against.

(*c*) In no case, even when a breakdown as above assumed takes place, should the voltage produced in line L_1 exceed 250 volts.

Bearing in mind the high voltages used in carrier telephony (for example, the plate voltage) an insulating transformer should be inserted between the carrier installation and line L_1, which transformer should be capable of withstanding without damage a potential of at least three times the maximum voltage which may occur under normal operation conditions in a carrier telephone installation.

(*d*) All connections to earth, made on the coupling devices, should be carried out in accordance with the usual rules covering the earthing of high tension installations imposed by each country.

(*e*) Regarding operating practice, the owner of the private lines should be responsible for the regular conditioning of the whole installation and for its maintenance in conformity with the rules outlined above.

EXACT DETERMINATION OF THE CHIEF CHARACTERISTICS OF PROTECTIVE DEVICES.

The International Consultative Committee—

Considering:—

That the chief characteristics of the various protective devices used in different countries, as already reported by Administrations and Operating Companies and tabulated hereinafter, do not appear to be based on the same principles of measurement and designation.

That, on the other hand, precise and well-defined data should be available for a comparison between the various forms of the same protective device.

Unanimously advises :—

That the chief characteristics of the protective devices used in various countries and tabulated in the following Appendix should be verified with due regard to the recommendations made in the Appendix, entitled : " Chief characteristics of the protective devices."

That Administrations and Operating Companies are invited to complete the information already supplied to the General Secretariat of the C.C.I. in conformity with these recommendations.

APPENDIX.

CHIEF CHARACTERISTICS OF PROTECTIVE DEVICES.

This note enumerates the constructional and functional characteristics of the protective devices which should be considered when a comparison is to be made between different types. When it has appeared useful the principle of a measuring method for determining the characteristics has been indicated. For certain characteristics an exact definition has been added.

The purpose of this note is merely a study of protective devices. In fact, the determinations indicated should be applied to several specimens of the same type and should be compared among themselves. When it is necessary to ascertain if samples conform with a standard, simplified methods may be used.

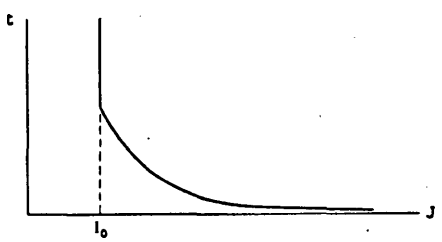
I. FUSES.

(*a*) **Description.**—Material and dimensions of the fuse wire; form and, when possible, method of replacing the fuse wire; if possible, particulars of operating. . . .

(*b*) **External form.**—Method of mounting and admission of current, accessibility. . . .

(*c*) **Resistance.**

(*d*) **Operating value.**—It is possible to plot a characteristic curve representing as a function of the current J flowing through the fuse (direct or alternating current), the time t required to blow the fuse. That curve is asymptotic on the one hand to the line $t=0$ and on the other hand to a line parallel



to the time axis. If I_0 is the abscissa of that line, its value may be adopted as the operating current of the fuse. (*See* curve.)

(*e*) **Calorific capacity.**—The calorific capacity of a fuse is the maximum energy which can be almost instantaneously absorbed by the fuse without blowing it. In practice it is sufficient to determine this value to within $\pm$ 10 per cent. To ascertain the calorific capacity, repeated discharges from a bank of condensers are sent through the fuse. If C is the capacity of this bank of condensers and V the voltage to which they are charged, then the energy absorbed by the fuse is $\frac{1}{2} CV^2$, provided the losses in other parts of the discharging circuit are negligible. The latter should be wired up with heavy conductors and all contacts should be good.

One can ascertain whether or no the losses in the discharging circuit are negligible, either by varying the capacity and the voltage or else by testing several fuses simultaneously. It is immaterial to the calorific capacity of a fuse, whether fuses are wired in series or parallel.

Since, during a thunderstorm, several atmospheric discharges may follow each other in almost immediate succession and that, therefore, heat may be stored up in the fuse, it is desirable to test with at least ten discharges, at intervals of ten seconds.

(*f*) **Voltage under which the current can be interrupted.**—When a fuse is connected to a source of direct current (or to a supply network) of high voltage and great power, it may be feared that the fusing of the wire may be followed by an arc. In order to ensure that an arc is not maintained in the cartridge of the fuse the following method may be used: in series with the fuse either a circuit breaker or else another fuse is connected which is capable of operating until a longer period has elapsed than is required for the fuse under test to blow. Thus, the operation of the circuit breaker or the larger fuse indicates the maintenance of an arc in the smaller fuse. In general, this test requires means which are not ordinarily at hand in telephone laboratories.

II. HEAT COILS.

All the characteristics listed under the title of fuses, with the possible exception of calorific capacity, should be considered in connection with heat coils or any other device used for the same purpose.

At any rate it is of great interest accurately to define the characteristic curve under (*d*) and the voltage referred to in (*f*) above.

It should also be noted whether or not the heat coil is of the regenerative type, either automatic or hand-operated. It should therefore be ascertained how many times a heat coil may be used.

III. LIGHTNING ARRESTORS.

(*a*) **Description.**—Nature, shape and arrangement of the electrodes and their external connection. Nature and atmospheric pressure surrounding the electrodes.

(*b*) **External construction.**—Method of mounting and entry of current, accessibility. . . .

(*c*) **Insulation.**

(*d*) **Operating voltage.**—If a continuous voltage is applied to the terminals of a lightning arrestor, and is then gradually raised, a value will be found above which the arrestor will operate; this is indicated by the flow of a current, which can be measured on an instrument.

The voltage thus defined may be called the operating voltage of the arrestor. Certain types of arrestor lend themselves to an interpretation of their function through the plotting of a characteristic curve, showing the relation between the continuous voltage at the terminals of the arrestor and the amount of current passing through it. In general, this curve presents several parts corresponding particularly to the functioning of the discharge and that of the arc. It is useful to determine (within perhaps $\pm$ 20 per cent.) the values of the current density, at which changes occur.

Heating-up of the arrestor should be avoided when obtaining the characteristic. Also, in case of high values, the time allowed for the current to flow should be reduced and the intervals between operations prolonged.

Incidentally, it will be of interest to observe how the voltage varies at the terminals of the arrestor when the testing current is applied for an appreciable length of time. Similarly, it will be of interest to observe how the operating voltage varies at the end of more or less prolonged operations of the protector.

An arrestor may be dissymmetrical, depending on the direction of the voltage applied; in that case the characteristic just defined will not be the same if the voltage is reversed. This point should be investigated.

Note.—When alternating current is used a rapid determination of the operating voltage may be made and the dissymmetry feature of the arrestor verified by means of an oscillograph, which shows the behaviour of the current and its wave form. For this investigation it is necessary to use a source of voltage free from harmonics.

(*e*) **Ruggedness.**—It is necessary to determine the life of the arrestor, during which it will not deteriorate, nor show important changes in the operating voltage after cooling, when passing currents of various strengths, increasing in value, step by step, from 0.1A up to the point where the fuse associated with the arrestor blows.

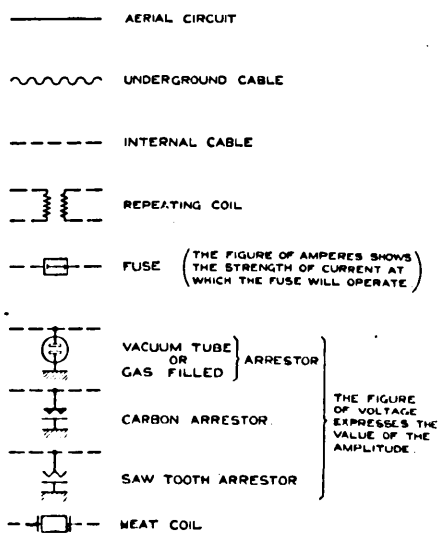
Since in practice a current greater than I_0 is interrupted in a given time (as shown by the curve, p. 255), it is necessary to ascertain that the arrestor will stand a large number of charges during the time required for the associated fuse to blow.

This test may be made with direct or alternating current, as required.

APPENDIX.

Tabular representation of protective devices used on telephone installations in various countries to protect personnel and installations against possible damage from power lines or from atmospheric discharges.

CONVENTIONS.



TOLL CIRCUIT IN UNDERGROUND CABLE (1,1).

ADMINISTRATION	EXCHANGE	LINE
GERMAN		CABLE, LOADING COILS, REPEATING COILS, TESTED WITH 1800 V 50 P.P.S. TO EARTH
A.T.&T.		
BELGIAN		
BRITISH	(a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. ORDINARY (a) 300-500 V. (b) 500-800 V. 3A; (a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. WITH REPEATING COIL (a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. (a) 300-500 V (b) 500-800 V. 3A 3A ASSOCIATED WITH A REPEATER	
FRENCH		
HUNGARIAN	0·5A 3 MIN GRADUALLY SUPPRESSED	
NORWEGIAN	0·5A 45 Ω. 425 V.	
DUTCH	0·25A 15 Ω	
SWEDISH	3A 700-1000 V	
AUSTRIAN		
CZECHO-SLOVAKIAN		

AERIAL TOLL CIRCUIT (1,2).

ADMINISTRATION	EXCHANGE A.	LINE	EXCHANGE B
GERMAN	0·5A 45 Ω. 5A APPROX 2000 V.		SAME AS EXCHANGE A
A.T.&T.	0·5A A 210 Ω. 10 Ω A OR WIRE OF 0·8 mm. 380 V.		SAME AS EXCHANGE A.
BELGIAN	0·5A OR 0·5A. 30 Ω. 3A > 250 V IN SPECIAL CASES VACUUM TYPE (320 V.)		SAME AS EXCHANGE A.
BRITISH	(a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. 3A (a) 300-800 V. (b) 500-800 V.		SAME AS EXCHANGE A.
FRENCH	1A 3A NON MULTIPLE SWITCHBOARD 800 V.		3A 0·5A 30 Ω 800 V MULTIPLE SWITCHBOARD
HUNGARIAN	0·5A 3 MIN. 5A 450 V. (750 V.)		SAME AS EXCHANGE A.
NORWEGIAN	0·5A 45 Ω. 3A 425 V.		SAME AS EXCHANGE A.
DUTCH	0·25A 15 Ω NEON TYPE 150-170 V.		SAME AS EXCHANGE A.
SWEDISH	0·25A 20 Ω. 3A 700-1000 V.		SAME AS EXCHANGE A
AUSTRIAN			SAME AS EXCHANGE A
CZECHO-SLOVAKIAN			SAME AS EXCHANGE A

SUBSCRIBER'S LINE IN UNDERGROUND CABLE (1,3).

ADMINISTRATION	CENTRAL EXCHANGE	LINE	SUBSCRIBER'S STATION
GERMAN			
A.T. & T.	0·54 A, 210 Ω, 350 V.		
BELGIAN			
BRITISH	EXCHANGE WITH LESS THAN 12 CIRCUITS AND WITHOUT EARTH CONNECTION.		WHERE THERE ARE LESS THAN 12 SUBSCRIBERS LINES AND NO EARTH CONNECTIONS.
	EXCHANGE WITH LESS THAN 12 CIRCUITS BUT WITH EARTH CONNECTIONS. (a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. 3A		WHERE THERE ARE LESS THAN 12 SUBSCRIBERS LINES AND NO EARTH CONNECTIONS.
			WHERE THERE ARE LESS THAN 12 SUBSCRIBERS LINES BUT WITH EARTH CONNECTIONS. 3A 0·5A, 15-60 SEC
	EXCHANGE WITH MORE THAN 12 CIRCUITS. (a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. 3A (a) 300-500 V (b) 500-800 V		WHERE THERE ARE LESS THAN 12 SUBSCRIBERS LINES AND NO EARTH CONNECTIONS.
			WHERE THERE ARE LESS THAN 12 SUBSCRIBERS LINES BUT WITH EARTH CONNECTIONS. 3A 0·5A, 15-60 SEC
			WHERE THERE ARE MORE THAN 12 SUBSCRIBERS LINES. 3A 0·5A (a) 300-500 V (b) 500-800 V 15-60 SEC.
FRENCH	0·5A, 30 Ω		3A
HUNGARIAN	0·5A, 3 MIN.		NO INDICATIONS.
NORWEGIAN	3A, 425 V.		NO INDICATIONS.
DUTCH	0·25 A, 15 Ω		
SWEDISH	0·25 A, 20 Ω, 3A, 700 - 1000 V.		NO INDICATIONS.
AUSTRIAN			
CZECHO-SLOVAKIAN			

AERIAL SUBSCRIBER'S LINE (1,4).

ADMINISTRATION	CENTRAL EXCHANGE	LINE	SUBSCRIBER'S STATION.
GERMAN	0·5A, 45 Ω, 350 V. 8A, APPROX 2000 V.		8A, APPROX 2000 V. 0·5A, 45 Ω, 350 V.
A.T. & T.	0·54 A, 210 Ω, 350 V. 10·5A OR WIRE OF 0·5 MM.		7A, 350 V.
BELGIAN	0·5A. LOCAL BATTERY > 220 V. 3A. 0·5A, 30 Ω. COMMON BATTERY		3A, > 220 V. IN SPECIAL CASES VACUUM TYPE 320 V.
BRITISH	(a) 0·5 A, 15-60 SEC (b) 0·5 A, 210 SEC 3A (a) 300-500 V (b) 500-800 V		3A 0·5A, 15-60 S. (a) 300-500 V (b) 500-800 V
FRENCH	NON MULTIPLE 1A OR 3A, 500 V. 0·5A, 30 Ω. MULTIPLE SWITCHBOARD		3A, 500 V.
HUNGARIAN	0·5A. 3 MIN. 5A, 450 V. (750 V.)		a 5A 0·2A OR b 0·2A 0·2A
NORWEGIAN	3A, 425 V.		NO INDICATIONS
DUTCH	0·25A, 15 Ω, NEON TYPE 150 - 170 V.		IF LENGTH OF SUBS. LINE IS GREATER THAN 500 M. NEON TYPE 150 - 170 V.
SWEDISH	0·25A, 20 Ω, 3A, 700 - 1000 V.		3A, 700 - 1000 V. IF LINE IS CROSSED BY HIGH TENSION LINES.
AUSTRIAN			
CZECHO-SLOVAKIAN			

TOLL CIRCUIT NOT ENTIRELY IN CABLE.(1,5).*

ADMINISTRATION	EXCHANGE A	LINE	EXCHANGE B.
GERMAN	0·5A 8A 45 S. APPROX 2000 V. OTHERWISE AS IN THE CASE OF A CABLE ENTIRELY UNDERGROUND	350 V. APPROX 2000 V.	8A 0·5A. 45 S. APPROX 2000 V. 350 V.
AUSTRIAN			
BELGIAN	NO SPECIAL INDICATIONS	>220 V IN SPECIAL CASES VACUUM TYPE (320 V)	NO SPECIAL INDICATIONS
BRITISH	(a) 0·5 A, 15-60 SEC. (b) 0·5 A, 210 SEC. 3A (a) 300-500 V (b) 500-800 V AS ABOVE	IN THE CASE OF SUBMARINE CABLES AND ALSO IMPORTANT UNDERGROUND CABLES, WHERE THE COST OF PROVIDING THE PROTECTION ARRANGEMENTS DO NOT EXCEED ½ THE PRICE OF THE UNDERGROUND CABLE TO BE PROTECTED 3A IN OTHER CASES.	(a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. 3A (a) 300-500 V (b) 500-800 V AS ABOVE
FRENCH	NO SPECIAL INDICATIONS	SAWTOOTH TYPE OR	NO SPECIAL INDICATIONS.
HUNGARIAN	NO SPECIAL INDICATIONS	450 V (750 V) 3A	NO SPECIAL INDICATIONS
NORWEGIAN	NO SPECIAL INDICATIONS	NO INDICATIONS	
DUTCH	0·25 A 15 S.	150-170 V NEON TYPE	NO SPECIAL INDICATIONS
SWEDISH	NO SPECIAL INDICATIONS	350 V 3A	NO SPECIAL INDICATIONS

* IT IS DESIRABLE FOR THE CABLE CIRCUITS, TO INDICATE THE BREAKDOWN STRENGTH OF THE DIELECTRIC BETWEEN THE TELEPHONE CIRCUIT AND THE SHEATH OF THE CABLE.

SUBSCRIBER'S LINE NOT ENTIRELY IN CABLE. (1,6).*

ADMINISTRATION	CENTRAL EXCHANGE	LINE	SUBSCRIBER'S STATION
GERMAN	0·5A 350V OTHERWISE AS IN THE CASE OF CABLE ENTIRELY UNDERGROUND	8A APPROX. 2000 V	8A 0·5A 45 S. APPROX 2000 V. 350V. NORMALLY AS 1,4.
AUSTRIAN			
BELGIAN	NO SPECIAL INDICATIONS	>220V IN SPECIAL CASES VACUUM TYPE (320 V)	NO SPECIAL INDICATIONS.
BRITISH	(a) 0·5A, 15-60 SEC. (b) 0·5A, 210 SEC. 3A (a) 300-500V (b) 300-800V		3A 0·5A, 15-60S (a) 300-500 V (b) 500-800 V
FRENCH	1A 3A OR 500 V. 0·5A 30 S. NORMALLY AS 1,3	NO INDICATIONS	3A 500 V. NORMALLY AS 1,4.
HUNGARIAN	NO SPECIAL INDICATIONS	8A 450 V. (750 V.)	8A
NORWEGIAN	NO SPECIAL INDICATIONS	NO INDICATIONS	NO SPECIAL INDICATIONS
DUTCH	0·25 A 15 S.	150-170 V NEON TYPE.	ONLY IN THE CASE OF A LENGTH OF MORE THAN 600 METRES
SWEDISH	NO SPECIAL INDICATIONS	700-1000 V.	NO SPECIAL INDICATIONS
CZECHO-SLOVAKIAN			

* IT IS DESIRABLE FOR THE CABLE CIRCUITS, TO INDICATE THE BREAKDOWN STRENGTH OF THE DIELECTRIC BETWEEN THE TELEPHONE CIRCUIT AND THE SHEATH OF THE CABLE.

TOLL CIRCUIT NOT ENTIRELY IN CABLE (1,5 CONTINUED).

COMPANY	CENTRAL EXCHANGE A	LINE	CENTRAL EXCHANGE B
A.T. & T.	† HEAT COIL. AIR GAP LIGHTNING ARRESTOR (350 V)	OPEN WIRE CONDUCTOR. SHEATH OF THE UNDERGROUND CABLE. SHEATH OF THE AERIAL CABLE. JUNCTION POINT BETWEEN THE UNDERGROUND AND AERIAL CABLES. X. AIR GAP LIGHTNING ARRESTOR (710 V.)	10·5 A. 5 MIN. AIR GAP LIGHTNING ARRESTOR (350 V)

† HEAT COIL CHARACTERISTICS { 0·35 AMPERE CONTINUOUS. 0·54 AMPERE NOT EXCEEDING 210 SECONDS

X. THE AIR GAP LIGHTNING ARRESTOR (710 VOLTS) IS PLACED BETWEEN THE OPEN WIRE CONDUCTORS AND THE SHEATH OF THE AERIAL CABLE. (IN ACTUAL PRACTICE, THIS IS DONE BY CONNECTING THE ARRESTOR TO THE SHEATH OF THE CABLE RATHER THAN TO GROUND AT SUCH JUNCTION POINTS BETWEEN CABLE AND OPEN WIRE LINE).

SUBSCRIBER'S LINE NOT ENTIRELY IN CABLE (1,6 CONTINUED).

COMPANY	CENTRAL EXCHANGE	LINE	SUBSCRIBER'S STATION
A.T. & T.	† HEAT COIL. AIR GAP LIGHTNING ARRESTOR (350 V)	OPEN WIRE CONDUCTOR. SHEATH OF THE UNDERGROUND CABLE. SHEATH OF THE AERIAL CABLE. JUNCTION POINT BETWEEN THE UNDERGROUND AND AERIAL CABLES. X. AIR GAP LIGHTNING ARRESTOR (710 V.)	‡ FUSE AIR GAP LIGHTNING ARRESTOR (350 V)

† HEAT COIL CHARACTERISTICS { 0·35 AMPERE CONTINUOUS 0·54 AMPERE NOT EXCEEDING 210 SECONDS

X. THE AIR GAP LIGHTNING ARRESTOR (710 VOLTS) IS PLACED BETWEEN THE OPEN WIRE CONDUCTORS AND THE SHEATH OF THE AERIAL CABLE. (IN ACTUAL PRACTICE, THIS IS DONE BY CONNECTING THE ARRESTOR TO THE SHEATH OF THE CABLE RATHER THAN TO GROUND AT SUCH JUNCTION POINTS BETWEEN CABLE AND OPEN WIRE LINE).

‡ FUSE { 7 AMPERES CONTINUOUS 10·5 AMPERES NOT EXCEEDING 5 MINUTES.

PRINCIPLES OF PROTECTION.

The International Consultative Committee—

Considering :—

That at the present time there exist considerable differences in the systems of protection in use, and that it would be of interest to unify these methods while making them simple, effective and economical.

Unanimously advises :—

1. That the principle of protection should be first of all to choose judiciously the requirements with respect to the construction of lines and installations as well as their conditions of installation, and that a complementary rôle should usually be assigned to the protective devices.

2. That, in general, any telephone circuit (long distance circuit, or subscriber's line) entirely in underground cable and having no direct earth connection nor any connection to installations connected to earth, should not have any protective device.

That, in this case, if the circuit is exposed to induction from power lines, the total longitudinal induced voltage should not exceed 60 per cent. of the breakdown voltage of any part of the cable circuit.

That, if the induced voltage exceeds this limit for a certain part of the circuit (*e.g.*, the repeating coils) it is necessary to replace the elements of the circuit which do not fulfil the preceding condition or to reduce the value of the induced voltage.

IDEAL PROTECTIVE DEVICE.

The International Consultative Committee—

Considering :—

That the protective devices at present in use have been developed, some to protect the installations against atmospheric discharges and others to protect against risk of contact with power lines or induction from these lines.

Unanimously advises :—

That an ideal device should satisfy the two given conditions.

That it appears as though such a device could be constituted by the following arrangement :—

1. A simple arrestor (with points, knife edge, etc.) of which the breakdown value should be about 2 000 volts.

2. A fuse of which the wire fuses in less than n seconds, when it carries a current between 0.5 and 1 amp—which does not give rise to an arc if to its terminals is applied a source of sufficient power and of which the voltage is 750 volts—which can support two consecutive discharges spaced at intervals of ten seconds, each involving at least eight joules.

3. A vacuum tube arrestor of which the breakdown voltage is about 300 volts and which can support without deterioration, on the one hand, the prolonged passage of a current which is insufficient to operate the fuse and, on the other hand, the passage of any greater current during the time required to operate the fuse.

Considering, on the other hand :—

That, at the present time, a fuse fulfilling these conditions does not exist,

Unanimously advises :—

That the Administrations and Operating Companies submit this programme to the manufacturers of their respective countries, inviting them to study its realisation.

PART II.

PROTECTION OF TELEPHONE CIRCUITS AGAINST CORROSION DUE TO ELECTROLYSIS.

I.—Advice of the International Consultative Committee concerning corrosion of telephone cable sheaths.

(1) *The International Consultative Committee—*

Considering :—

That research on faults on underground cables and the repair of these faults may involve considerable cost; that the interruptions in the service which may result from the presence of these faults should be avoided with great care; that even if the repair has been carried out as well as possible, the quality of the cable may be decreased and its normal life reduced.

Unanimously advises :—

That it is desirable in the interests of long distance telephony to publish certain information capable of assisting the different Administrations and Operating Companies in overcoming the effects of electrolysis due to return currents from electric traction and the effects of chemical action on lead-covered cables.

(2) *The International Consultative Committee—*

Considering :—

That certain appropriate measures taken at the time of installation or during the maintenance of telephone cables can reduce the importance of electrolytic effects, and that the most effective means of overcoming the damage is certainly to diminish the importance of their cause, that is to say, to prevent the establishment of excessive difference of potentials between the return conductors of the traction current and the lead sheath of the cables.

That this result can be obtained by observing certain technical rules during the installation of the traction lines, by means of a proper adaptation of the feeding network and of the return current network to the operating conditions of these lines, and by means of particular care taken in the installation of this network.

That, nevertheless, in order to be able to define with sufficient precision these different precautions, it is necessary to take into account the general conditions of operation of the traction system.

That in the case of railway lines of general interest, the present knowledge on the question does not yet permit the establishment of rules which would be applicable to these lines, but that the present development of electric traction on the networks of general interest justifies the continuation of the studies undertaken in this respect.

That, on the other hand, the adoption of proper precautions to be taken for each particular case, in the maintenance of telephone cables, often assumes sufficient knowledge of the operating conditions of the neighbouring railway lines; also that the interests of the Telephone Administrations and Operating Companies do not differ, in this case, from the interests of other Administrations.

Unanimously advises :—

That it is desirable that the study of measures of protection against stray currents should be followed by the C.C.I. in collaboration with the international organisations officially representing the different interests in question, such as the International Union of Tramways, Local Railways and Public Motor Transport, the International Union of the Gas Industry and the International Union of Railways.

That it is to be recommended that each Administration or Operating Telephone Company, while applying to its underground networks measures capable of increasing their security from risk of damage due to electrolysis, will enter into collaboration with the Administrations of electric traction networks, as well as with the other interested Administrations (water, gas, electric distribution) in order to study in common, in each particular case, the best conditions for installation, maintenance and supervision of the networks, and jointly to take all useful precautions.

(3) *The International Consultative Committee—*

Considering :—

That the proposed Recommendations (Section II) only deal with the employment of earth plates (déversoirs) and the practice of electric drainage with extreme reserve, a definite and unanimous opinion not yet having been given;

Unanimously advises :—

That the attention of the interested Administrations and Operating Companies should again be drawn to the necessity for continuing the study of the questions concerning electric drainage and earth plates (déversoirs).

(4) *The International Consultative Committee—*

Considering :—

That a first project of provisional recommendations concerning the measures to be taken for the protection of cables against electrolytic corrosion, published by the C.C.I. in 1927 (and reprinted in the Yellow Book of the C.C.I. 1930, pp. 653-677) has for three years been examined by Administrations and Telephone Operating Companies and by the International Union of Tramways, the Railways of local interest and Public Motor Transport (U.I.T.).

That this project has been the object of an important study by the International Union of Tramways, a study which has given rise to detailed discussion on the part of very competent authorities on electrolysis matters.

Considering also :—

That, with the exception of a few secondary points, the principal difference between the two regulations drawn up respectively by the C.C.I. and by the U.I.T. is that the U.I.T. fixes a maximum of 2.5 volts for the difference of potential between any two points of the network, while the C.C.I. limits to 0.8 volt the value of the voltage between the rails and earth in the corrosion zones.

Considering besides :—

That in order to determine whether one or the other of these limits is exceeded a preliminary calculation is always made of the distribution of current in the system of rails and return feeders, on the assumption that this system is perfectly insulated from earth, and that this calculation is evidently the same whatever conclusions are to be drawn from it.

Considering, on the other hand :—

That the difference between the two regulations results from the fact that after the preliminary calculation the C.C.I. consider the effect of the leakage resistance between the rails and earth in order to determine the points of zero potential in the network, on the assumption that the currents which flow through this leakage resistance do not change essentially the calculated distribution of currents and voltages in the system of rails and return feeders.

Considering, in addition :—

That the C.C.I. calculation uses for the leakage resistance mean values which agree with those found by the Bureau of Standards (U.S.A.) as the result of a long series of measurements, and which also agree essentially with those indicated in the study of the U.I.T.

Considering :—

That for this reason it should be considered that the regulation of the C.C.I. based on a calculation which takes into account the two factors, rail resistance and leakage resistance, is more satisfactory from the technical point of view than that of the U.I.T., which only considers the first.

Considering also :—

That it is possible to make certain modifications in the original project of recommendations drawn up by the C.C.I. in order to take into account the justified remarks drawn up by the U.I.T., and in particular to state that the rule of the maximum potential of 0.8 volt should not be applied to sections of track for which the mean leakage resistance between rails and earth is high.

Unanimously advises :—

1. That instead of the project of recommendations concerning the measures to be taken to protect cables against electrolytic corrosion, appearing in the Yellow Book (pp. 653-679), should be substituted the following new project of which the Administrations and Operating Companies should make the greatest possible use.

2. That this project be brought officially to the knowledge of the C.M.I. and that this commission be invited to carry out tests and to exchange views necessary in order to arrive at an agreement between all interests on a text for the recommendations.

II. Proposed Recommendations concerning the measures to be taken for the protection of cables against electrolytic corrosion.

In elaborating the present Recommendations, the C.C.I. proposes to gather together certain information capable of assisting the different Administrations and Operating Companies to overcome the effects of electrolysis due to return currents from electric traction.

At the present time, while it is relatively easy to detail the principle of most of the technical measures to be taken, it is scarcely possible to fix their precise limits. The measures that can be proposed can only result in a compromise between the technical aim to be attained and the economical possibilities of realising this.

It has seemed useful, nevertheless, in order to fix the ideas, to give some precise numerical values for the limits to apply to the technical measures recommended. It is in this spirit that the numerical values in the text of the Recommendations have been determined.

From another point of view the Recommendations can only be considered as expressing the opinion of the majority of the technical advisors taking part in the work of the C.C.I., certain Administrations and Operating Companies not accepting all the numerical limits proposed. All the questions of an administrative and economic order, and, in particular, all the questions of regulations and legislation relative to the problem of the proximity of electric traction lines and telephone cables, are outside the sphere of the Committee and have been left on one side.

In particular, the Committee has abstained from entering into details of the rules of procedure, which should be followed in the reports between the Administrations and Operating Telephone Companies and the services of electric traction, production or distribution of electricity. It believes, however, that it can make a very general recommendation.

In order to obtain every advantage from the measures to be taken for the protection of telephone cables, and in order to facilitate their practical application, it is desirable that the telephone or electrical services interested should collaborate with the greatest goodwill. The reciprocal interchange, in a systematic and regular manner, of all useful information relating to the construction of existing or projected lines, to the changes of conditions of operating of existing or proposed installations in the neighbourhood, is much to be recommended.

A. General.

1. According to tests made up to the present, the stray currents resulting from alternating-current installations of usual frequency do not exercise any harmful influence on metallic masses in the soil. The danger of electrolytic corrosion results only from direct-current installations.

Experience has shown that a network of pipe lines or of cables can be considered as practically free from corrosion due to stray currents, if it nowhere approaches closer than approximately 200 metres to a direct-current installation, which normally or accidentally has one conductor earthed, or to all works, structures or ducts, which are metallically connected with said installation.*

In certain cases, however, such as that in which the earth is a very good conductor or in which a water course is present, this distance of 200 m may not be sufficient.

In their present form these recommendations apply only to corrosion caused by electric traction installations. Electric distribution installations will be subject to special recommendations.

Amongst electric traction installations themselves the recommendations do not concern traction lines with independent sub-structure, when the latter is insulated from earth throughout its entire length (wooden sleepers, special insulation at level crossings, etc.). For traction lines with independent sub-structure, and notably for railway lines of general interest, special recommendations will be formulated when actual data on this question have been obtained.

2. From the point of view of the danger to which underground metallic conduits are exposed it is necessary to distinguish, in a traction network established along a road, between the region in which the pipes and the cables are at a potential less than that of the rails, where, as a result, the current enters the conduits, and that in which the conduits have a voltage greater than that of the rails and where, in consequence, the current leaves the latter.

In the following text are used the expressions " entrance zone " to designate the zone where the stray currents enter the sheath of the cables, and " exit zone " (or zone of anode corrosion), the zone where the currents leave the sheath.

3. When conditions exist so that an attack on pipes or cables by stray currents from the traction installation may be produced, it is necessary to apply special measures to avoid dangerous corrosion as much as possible.

4. Measures of protection should be applied in the first instance to the construction and operation of the electric traction system, the latter being the first cause of the stray currents.

Besides, these measures are generally easier to apply technically than equally effective measures applied to the cable. The latter can, in general, only be usefully applied in new installations or at the time of an important reconstruction. When installing new metallic conduits in the neighbourhood of existing or projected traction systems, these conduits should themselves be protected against corrosion by appropriate measures.

In addition, it should be remarked that, apart from the electrolytic or chemical action which they can produce, the stray currents can be harmful by themselves—for example, where, at the crossing of tracks of general interest of which the rails carry signalling currents, they are capable of using these tracks. This consideration is added to the preceding ones in order to justify the necessity of limiting as much as possible the currents which pass to the earth in a power installation.

5. The measures proposed here result from a compromise between the technical aim to be attained and the economic possibilities of realising it: although they are not sufficient to overcome all danger from corrosion, they will probably ensure that the normal life of a cable will not be much reduced by electrolysis.

* New tests will be made to determine, exactly, the distance at which the danger of corrosion may be considered negligible.

6. From the technical point of view it is desirable that the application of these measures be made the object of a systematic collaboration between all the interested services (electric railways, electric distribution, gas, water, etc.).

B. Protective measures applicable to electric traction networks.

Generalities.

1. Experience has shown that from the point of view of the extent of danger from corrosion it is necessary to take into account the following factors :—

(*a*) Situation and extent of underground metallic networks;

(*b*) Nature of the track and its foundations;

(*c*) Position of the points of connection of the return feeders to the rails.

In practice, two distinct types of traction network occur; urban and suburban tramway systems. The first are usually characterised in the following way :—

(*a*) In practically the whole of their extent they are superimposed on underground metallic networks relatively close together (water, gas, power cables and telephone cables);

(*b*) The track is formed of grooved rails buried flush with the surface of the ground;

(*c*) They are supplied by a generating station or substation placed at the centre of the points of connection to the rails of the return feeders arriving at the station.

The suburban tramways, in their turn, generally present the following characteristics :—

(*a*) They are situated in regions where underground metallic networks are few or non-existent;

(*b*) The track is formed of flanged rails on an independent road bed;

(*c*) They are supplied by a generating station or substation situated outside towns or their immediate outskirts.

In the case of both urban and suburban tramways the danger of corrosion will be less, the smaller the difference of potential between the rails and the earth at any point; the efforts of the traction companies should therefore be directed towards that object. However, since the cause of electrolytic corrosion is not the voltage between the rails and earth but the current produced by this voltage, and since this current depends not only on the magnitude of the voltage but also on the leakage resistance between the rails and earth, it is clear that, other things being equal, it is not necessary to be so severe with a suburban tramway as with an urban tramway, since the track of the former is usually much better insulated from the earth than that of the latter. This is why the present Recommendations only consider the limitation of the voltage between rails and earth in the case of urban tramways.

The above having been pointed out, it should be mentioned that the conditions set out above under (*a*), (*b*) and (*c*) can be combined in various ways and that in practice networks occur which are neither urban nor suburban tramways, according to the strict meaning of the above definition, or which can be considered as either one or the other. Each particular case should be considered on its own, and the present Recommendations should be broadly interpreted.

For example, an urban tramway network, supplied by a generating or substation situated outside the town or its immediate suburbs, would be classed as an urban tramway in the district covered by the town and its immediate suburbs and as a suburban tramway outside that district, and in particular at the points of connection of the return feeders to the rails in the extra-urban zone. Inversely, a suburban tramway supplied by a generating or substation situated in a town or its immediate suburbs would be considered as an urban tramway in the zone where underground metallic networks are frequent, assuming that the tracks extend over this zone.

2. In order to reduce the amount of stray currents, an attempt should be made to :—

(*a*) Prevent current flowing into the earth by ensuring as good an insulation as possible of the traction return current system and by reducing the voltage difference between the rails on the earth;

(*b*) Facilitate the return of current by the rails by ensuring their good conductivity.

Measures in connection with the track :—

3. It is necessary as far as possible to place the rails on a well-drained foundation of low conductivity.

All metallic contact between the rails and conducting structures (bridges, lightning rods, lamp standards, etc.) in contact with underground metallic pipe lines should be avoided.

4. As the conductivity of the rails themselves is determined by their profile it is desirable to maintain carefully the good conductivity of all joints.

5. The resistance of a joint should not exceed that of 3 m of rail, except joints at crossings and points. Further, the increase in the resistance of a section of track due to the joints should on an average not exceed 10 per cent. of the resistance of this section without joints.*

At points and crossings, joints in grooved rails are difficult of access because they are buried in the road ; furthermore, they are subjected to greater mechanical forces, in particular, the central pieces or the tongues. It is therefore not possible to apply to these joints the same regulations as those in other parts of the track. For these reasons, at points and crossings, grooved rails should satisfy the following conditions :—

(*a*) Joints, immediately after installation or after any important repair should not have a resistance greater than that of 3 m of rail ;

(*b*) Joints, which a subsequent check shows to have a resistance higher than that of 20 m of rail should be put into repair as soon as possible.

At points in the case of flanged rails the inside rails cannot be considered as participating in the conductivity, because, in general, the tongues of movable points are not shunted by electrical bonds. In the same way the central pieces of branches and crossings, in the case of flanged rails, can only be bridged by bonds of great length and consequently of high resistance. This is why it is necessary to insist that the resistance of joints in the outside lines of rails should be maintained as low as possible.

This condition is easy to fulfil as flanged rails are easily accessible. Consequently, at branch lines and crossings, the flanged rail joints should satisfy the following conditions :—

(*c*) The resistance of each joint of the two outside lines of rails should never exceed the resistance of 3 metres of rail ;

(*d*) If the transverse connections satisfy the conditions of paragraph (9) the tongues of the points need not be shunted by means of special bonds.

6. In order to maintain the track in the best possible condition from the point of view of its conductivity, it is recommended that once a year all points and crossovers should be verified, as well as joints in sections of the track for which calculations have shown a value of mean voltage drop exceeding 0.0005 volt per metre. (The definition of mean voltage is given in paragraph 12 below.)

It is also recommended that the resistance of all other joints should be measured every five years. They should be repaired as soon as possible if the measured resistances exceed the values of paragraph 7 of this chapter.

An exception is made for welded joints which should nevertheless be examined for cracks each year. Those which are defective should be repaired.

7. To equalise the current density as far as possible in all the lines of rails of a track or of parallel tracks, transverse connections should be made.

At points and cross-overs a transverse connection should be placed between all the lines of rails, before and after the point or cross-over.

The dimensions of the transverse connections should be arranged so that the resistance measured between any two points on two parallel lines of rails does not exceed, per metre of distance between

* A section of track is defined as a continuous section which contains no cross-over, no points and no connection to return feeders.

the two lines of rails in question, 1 milli-ohm in the case of grooved rails and 1.5 milli-ohms in the case of flanged rails.

Immediately before and after points or cross-overs in the case of flanged rails, this resistance should not exceed 0.25 milli-ohm.

Return feeders.

8. The distribution of potential at points on the rails can be controlled by using return feeders whose action is regulated, if necessary, either by means of additional resistances or by means of automatic boosters. The load can also be divided between several generating stations.

9. The return feeders as well as the busbars should be insulated from earth throughout their whole length. This insulation should be checked periodically. If the rails are connected to the negative terminal of the generators, it is necessary to choose as far as possible for the connections of return feeders situations where the earth is dry and distant from large pipes and cables, since it is in the neighbourhood of these points of connection that the danger of electrolytic corrosion is most pronounced.

10. The connections between return conductors and rails should be maintained in good condition.

Polarity of contact wires.

11. It is possible to reduce the danger of corrosion by means of the voltage of the contact wires.

When the positive pole is connected to the contact line, the zones of anodic corrosion are found in the neighbourhood of the points of connection to the return feeders. When the negative pole is connected to the contact line the zones of anodic corrosion are distant from these points and, in addition, these zones tend to follow the movements of the tramcars.

In order to reduce the harmful effect of stray currents, use may be made either of a periodic reversal of the polarity of the contact wires (which, in the case of a daily reversal, can produce a reduction of three-quarters) or of a three-wire system of supply.

The best condition in each case can be chosen from a study of the local conditions.

It should be noted that the reversal of the polarity of the contact wires raises certain operating difficulties in the case of networks supplied from several sub-stations. In addition, in large towns in which separate networks occur having crossing points, the adoption of this measure for one of the networks necessitates the use of special arrangements to ensure the installation of this network with respect to the others at points of crossing.

Justifying Calculations.

12. In order to verify whether the arrangements taken to ensure the return of current are satisfactory (in particular the choice of locations for the connections of return feeders and the distribution of potentials), calculations can be made to see whether the mean voltage drops along the rails and the differences of mean potential between the rails and earth* remain within the limits given below. The principle of the method of calculation is indicated in Appendix I.

13. On any section of the track of an urban tramway, the mean drop of voltage per metre, calculated on the assumption of an increase of rail resistance of 10 per cent. at the joints (*see* paragraph 6), should not be greater than 0.001 volt.

14. The mean voltage drop per metre of a section of the track of a suburban railway calculated as indicated in paragraph 12 should not exceed 0.0012 volt in sections on roads and should not exceed 0.0014 volt in sections with independent road bed.

* The differences of mean potential or mean voltage drop are defined as the values obtained by calculations for the different sections of track, taking as the power in a given section, the mean power, *i.e.*, the number of kilowatts obtained by dividing by 24 the number of kilowatt hours supplied on the average to the contact wire during a working day.

15. The mean voltage drop between two points of a tramway (urban or suburban) should not exceed a number of volts equal to twice the distance in a straight line between these two points expressed in kilometres.*

16. In zones of territories supplied by an urban tramway where stray currents leave pipe lines or metallic cable sheaths, the mean differences of potential calculated between rails and earth should not exceed 0.8 volt along sections of rail having a small resistance to earth (*e.g.*, buried rails).

For sections with a high average resistance to earth (*e.g.*, flanged rails on a separate road bed) it is not necessary to limit the mean difference of potential between rails and earth.

Methods of electrical measurement.

17. Measurements carried out in accordance with the methods given in Appendix 2 permit the state of the network to be verified in practice. They constitute an approximate check on the results of the calculation of voltages or mean differences of potential.

For very extensive networks, for which the calculation in accordance with paragraph 12 would be too complicated, measurements are indispensable to verify whether their condition conforms with the regulations of paragraphs 13, 14 and 15.

C. Protective Measures applied to Underground Cable Networks.

1. In order to avoid electrolytic corrosion it is necessary to attempt to reduce as much as possible the flow of stray currents in the cable sheaths in an electrolytic medium. To do this it is necessary, principally, to reduce the intensity of the stray currents flowing in cable sheaths by increasing the insulation of the sheaths with respect to earth and with respect to the traction network. In certain cases, on the contrary, it may be advantageous to provide a metallic path in order to prevent the flow of current direct from the sheath to the electrolytic medium.

2. The cables should be placed as far as possible from tramway installations; the crossings of the tramway lines being the dangerous points, it is necessary to reduce their number as much as possible.

3. When studying cable routes, it should not be forgotten that certain soils favour electrolytic corrosion (especially dampness, organic substances, soluble alkalis, bases and acids, etc.)

4. All metallic contact between the cable sheaths and conducting objects or structures in connection with the tracks of traction systems should be avoided.

5. It is necessary to avoid as far as possible infiltrations and stagnant water in the conduits as well as in the connection boxes or in the manholes.

6. In manholes and in terminal boxes, as well as at junction points, bare cables should be connected together by means of metallic connections soldered to the sheaths.

In cases where the underground conduits containing telephone cables are constructed of metallic pipes, these should also be connected electrically at these points.

7. A simple layer of insulating paint or a thin insulating covering provides very little guarantee against penetration by water, and cannot provide a permanent protection against corrosion. Such insulating layers are often found to be dangerous, since, after a certain time, at points which have become uncovered, a more intense corrosion takes place.

8. When the insulating sheath which covers the cable sheath is sufficiently thick and is itself protected, both from the mechanical and from the chemical point of view, by armouring or by some similar

* Although the conditions of paragraphs 13 and 14 seem to be sufficient from the point of view of electrolytic corrosion, other considerations such as telegraphy or signalling on telephone lines with earth return make it desirable to fix a maximum limit for the difference of instantaneous voltage between any two points on the tramway line.

arrangement (cable sheath, conduits of Zores iron, etc.), the protection against electrolytic corrosion can be considered sufficient. Such means of protection are recommended, particularly in the following cases : crossings by cables of tramway lines, crossing over metallic bridges, proximity to metallic structures connected more or less to the track.

9. It has been proposed to increase the electrical resistance of cable sheath by installing insulating joints with a view to preventing electrolytic trouble. These insulating joints should only be installed at points where the ground is sufficiently dry. They should be made so as to give mechanical resistance, durability and imperviousness.

In the case of several cables placed in the same conduit and arriving at the same point, the final use of insulating joints should be made for all of them. Their use should be avoided for cables subject to serious induction from direct or alternating current lines.

10. Earth plates buried in the earth and connected to the cable sheath (déversoirs) present several of the disadvantages of drainage connections*; it is advisable to restrict their use to points where the current leaves the cable sheath, and never to use them in regions where it is not possible to ensure that the earth plate will never be positive with respect to the cable sheath.

It does not seem that this procedure should be recommended for the protection of cables against electrolysis due to return currents from traction networks, a change in the distribution of these currents (produced, for example, by a modification in the traction network) being capable of modifying the polarity of some of these earth plates with respect to the cable sheath.

D. Protective Measures by means of Electric Drainage.

1. Under the heading of electric drainage is included a system comprising the use of metallic conductors for connecting to the return current network of the traction system certain points of the cable sheath which without drainage would tend to become positive with respect to the earth. The object is to conduct by a metallic path to the generating station the current which flows in the cable sheaths in such a manner as to decrease the amount of current which leaves these sheaths and enters the earth.

2. The use of drainage raises a certain number of different kinds of objections :—

This practice is very costly (cost of installation, of maintenance and of inspection high).

It can become ineffective as a result of accidental alteration in the distribution of the currents circulating in the cables; in particular the magnitude of these currents can become too great; on the other hand, cable may be exposed to cathode corrosion at places where the earth is of an alkaline nature.

It can become a cause of danger to telephone installations when a short circuit is produced on the traction network, and a cause of danger to the personnel dealing with the maintenance or operation of the telephone cables when the continuity of the rails has become broken by accident.

Finally, drainage, having as its effect the increase in the extent of the return current network of the traction system in all directions, can increase considerably the probability of corrosion at some point in the cable network or in neighbouring metallic conduits.

3. However, these disadvantages can be considerably decreased in certain cases—for example, when only a single traction line exists and where the route of the telephone cables is parallel to this track and has no branches. In such a case drainage connections can be permitted on the condition that a relatively small quantity of current is drained; this quantity should not exceed that which is necessary to prevent the harmful effect of electrolysis.

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* *See* Section D in connection with this subject dealing specially with electric drainage.

4. In all cases where a drainage system is adopted it is necessary that this system should be established in accordance with the following principles:—

(*a*) The most convenient point for making the connection to the cable sheath is the point where measurements show that the current leaving the cable to enter the earth has the greatest possible value. It is necessary, in order that the drainage shall be satisfactory, that the potential of points where the connections are arranged, which were positive with respect to the earth before the adoption of this measure, should become, on the contrary, lower than the voltage of the earth in the neighbourhood.

(*b*) Drainage connections should only be installed at the negative busbar of the traction current generator or at points where the return feeders are connected to the rails.

(*c*) The drainage should be arranged in such a way that the cable sheath being drained has throughout its length a negative potential with respect to the earth.

(*d*) It is essential to reduce all drainage to the minimum necessary for the protection of telephone cables. This can be done either by the choice of a suitable section of the conductors used for the drainage or by the use of additional resistances.

(*e*) An effective watch should be kept in order to check the conditions of operation of the drainage system: periodical measurements of drainage current are necessary. To this end all useful arrangements should be taken during the installation of the system to enable these measurements to be carried out easily.

(*f*) It is equally necessary to take care of the possibility of being able to interrupt the drainage connections at all times, when, apart from this precaution, currents could circulate of reverse polarity and of magnitude or of duration capable of leading to damage.

(*g*) It is necessary, finally, to install fuses in drainage connections or to use circuit breakers adapted to local conditions in order to interrupt the connection in case of short circuits on the traction network.

APPENDIX I.

TO THE RECOMMENDATIONS CONCERNING THE MEASURES TO BE TAKEN FOR THE PROTECTION OF CABLES AGAINST ELECTROLYTIC CORROSION.

PRINCIPLE OF THE METHOD TO BE FOLLOWED FOR CALCULATING THE DISTRIBUTION OF RETURN CURRENTS IN A TRAMWAY NETWORK.

In order to avoid electrolytic corrosion it is necessary to reduce, as far as possible, differences of potential between different points of the rail and the earth.

This is obtained particularly when the sections of track carrying too great a value of current are discharged conveniently by means of return feeders of sufficient cross-section connected to the rails at properly chosen points. The method of calculation indicated here serves as a guide in the choice of these arrangements.

It would be possible to determine exactly the distribution of return currents in the rails and in the earth as well as the distribution of potentials, if the following information was known :—

The geometric configuration as well as the electrical characteristics of the track network.

The position of the return feeders as well as their electrical characteristics.

The insulation resistance of the rails with respect to earth at each point of the track network.

The conductivity of the earth at each point.

Finally, the values at each instance of the current entering the rails at each point of the network where there is a locomotive. It is evident, also, that these values of current entering the rails depend on the configuration of the feeder network and the electrical characteristics of this network, as well as on those of the machines, and, finally, on all the data given above.

Nevertheless, as the effects of electrolysis depend, not on the instantaneous values of the current, but on their integral with respect to time, it is sufficient to take into account in the calculations the mean values of the current.

It should be remarked that certain of the data necessary for the exact solution of the problem cannot be known. Nevertheless, in practice the approximate solution is relatively easy of calculation, and permits a sufficiently exact idea to be obtained of the distribution of the potential which determines the extent of the electrolytic action.

It is possible in effect to assume, in order to simplify the calculations as far as concerns the electrolytic effect, that everything takes place as if the mean values of the current supplied to the rails by the generators had the same value per unit length at all points in the same section of track.

The values of these currents that must be introduced into the calculation can be deduced, either from the readings of instruments installed in the locomotives, if it is a question of a system already established, or, in general, from empirical relations giving the consumption of the machines as a function of the weight transported, of the speed, of the gradient of the track, etc.

In addition, for a first approximation, as long as the distribution of currents in the rail network and the distribution of potential along this network are studied, it seems permissible to neglect the losses of current along the rails.

These losses are small in general, and, in addition, the better the network is established the smaller are these losses.

The only effect of neglecting these losses will be that the differences of potential determined between the points and the rail will be larger than those present in reality.

Experience has shown that when the differences of potential calculated under these conditions do not exceed the value of 0.8 volt specified in paragraph 16 of Section B of the Guiding Principles, the damage caused by the corrosion is reduced to permissible limits.

In any case, if it is assumed that the losses of current in the earth are negligible, the presence of the earth can be neglected in the calculation of the distribution of currents in the rail network and of the distribution of potentials along this network.

This calculation can be made in the following manner :—

1. The mean linear density of the feeder current is known at each point of the rail network. The value I of the total current entering the whole network can thus be determined.

2. Currents entering the rail network can only leave by the feeders ; the sum of the currents leaving by the feeders is thus equal to I.

3. Suppose, to start with, that there exists a single feeder F_1 of known position. Knowing the value of the current entering at each point, and also the value I_{F1} of the current leaving by the feeder, which in this case is equal to I, we can determine absolutely (and independently of all electrical characteristics of the feeder) the value of the current which passes each point in the rail network. This determination is made by means of Kirchhoff's laws. By applying Ohm's law the value of the potential at each point is obtained, the potential of reference being that of a point chosen arbitrarily.

Let M be any point in the rail network.

Assume the following symbols :—

I_{M1}, the mean value of the current passing the point M,

V_{M1}, the mean potential at this point (the second index **1** indicates that I_{M1} and V_{M1} have been calculated on the assumption that all the current I leaves by the feeder F_1).

4. This being so, consider the case where p feeders are used, F_1, F_2, F_i, F_p, of which the position is known.

The preceding calculations can be repeated for each feeder, assuming that it exists alone.

Denote by :

I_{M1}, I_{M2}, I_{M_i}, I_{Mp}, the different values of current which passes the same point M of the rail network.

V_{M1}, V_{M2}, V_{M_i}, V_{Mp}, the different values of potential of the same point M (the potential of reference being that of an arbitrary point, but the same in all cases) calculated on the assumption of the existence of a single feeder.

It is important to note that these quantities can be calculated once and for all from the values of current entering the network and the position of the feeders, independently of all electrical characteristics of the feeders.

This having been done, denote by I_{F1}, I_{F2}, I_{Fi}, I_{Fp}, the values of currents leaving feeder F_1, F_2, F_i, F_p.

We have, therefore :—

$$\sum_{i=1}^{i=p} I_{Fi} = I \qquad \text{.....(1)}$$

Also the value of current at a point M will be equal to :

$$I_M = \frac{\sum_{i=1}^{i=p} I_{Fi}\ I_{Mi}}{\sum_{i=1}^{i=p} I_{Fi}} \qquad \text{.....(2)}$$

The value of potential at point M will be :

$$V_M = \frac{\sum_{i=1}^{i=p} I_{Fi} V_{Mi}}{\sum_{i=1}^{i=p} I_{Fi}} \qquad \text{.....(3)}$$

5. Thus, on the assumptions made up to the present, the knowledge of the value of the currents leaving each feeder permits the complete determination of the distribution of current in the rail network as well as the distribution of potentials.

In the application we can start from different data, according to the object of the study. We can thus start with the value of the current which leaves the rails at each feeder. In order to obtain this result effectively, it is necessary to determine the electrical characteristics of the feeders in such a way that they satisfy certain conditions.

Let R_1, R_2, R_i, R_p, be the resistance to be given to each of the feeders.

Denote by V_1, V_2, V_i, V_k, V_p, the values of potential at points 1, 2, i, k, p, where these feeders are connected to the rails.

According to the general equation (3), the expression for this is :—

$$\left.\begin{aligned} V_1 &= \frac{\sum_{i=1}^{i=p} I_{Fi} V_1}{\sum_{i=1}^{i=p} I_{Fi}} \\ V_k &= \frac{\sum_{i=1}^{i=p} I_{Fi} I_{Mi} V_k}{\sum_{i=1}^{i=p} I_F} \end{aligned}\right\} \qquad \text{.....(4)}$$

As all the feeders are connected to the same busbar at the generating station, we must have :—

$$V_1 - R_1 I_{F1} = V_k - R_k I_{Fk} = V_p - R_p I_{Fp} \qquad \text{.....(5)}$$

These p equations (4) and these $(p-1)$ equations (5) are not sufficient to determine the $2p$ unknowns (values of V_k and values of R_k). We can, therefore, for example, fix the arbitrary value of one of these unknowns.

It should be noted that it is nevertheless necessary, in order that the integral solution should have a physical meaning, that the values found for the different resistances should be positive.

We can also determine the distribution of return currents in the different feeders in such a way that the points where all the feeders are connected to the rails are at the same potential.

The system of equations to be solved is thus :—

Relation (1).

The p equations (4).

To which must be added the $(p-1)$ equation (6).

$$V_1 = V_2 \ldots = V_k \ldots = V_p \qquad \text{.....(6)}$$

There are thus the total of $(2p)$ equations to calculate $2p$ unknowns (the values of I_{Fk} and of V). The solution of the problem is thus completely determined.

We can finally determine what is the distribution of currents in the rail network when the return feeders have a resistance determined in advance.

Let V_k be the value of potential at a point where feeder F_k is attached; R_k the resistance of this feeder.

The system of equations to be solved is therefore:

Relation (1).

The p equations (4).

The $(p-1)$ equation (5).

There are thus $2p$ equations to calculate $2p$ unknowns (the values of I_{Fk} and of V_k). The solution to the problem is again determined.

6. In any case, when the values of the current leaving by each feeder are determined we can, by means of equation (3), calculate the distribution of potentials along the rails, the potential of reference being that of an arbitrary joint chosen at the start. This permits us to ensure that the mean drop in potential per metre, and the mean drop of potential between any two points of the networks, shall not exceed the limiting values indicated in paragraphs 13, 14 and 15 of Section B of the Recommendations.

It is interesting to know, in order to determine the importance of circulating currents in the earth capable of producing electrolysis, the difference of potential existing between the rails and the earth. In fact, the value of the current density leaving the rails to enter the earth, or leaving the earth to re-enter the rails, is at each point proportional:

To the difference between the potential of the rail and the potential of the earth.

To a certain co-efficient representing the losses of the track with respect to the earth.

Denote by i_M the density at any point M of the current leaving the rails to enter the earth. If at this point the current leaves the earth to re-enter the rails, i_M will be negative.

Let V_M be the potential of the rail at point M and V_{Ms} be the potential of the earth in the neighbourhood of point M, measured with respect to the potential of reference which has already been mentioned.

Let C_M also be the coefficient of leakance of the track at point M per unit length of track.

We have therefore:—

$$i_M = C_M (V_M - V_{Ms}) \quad \text{.....(6a)}$$

Nevertheless, the variations of potential of the earth along the rails of an electric traction network are always considerably smaller than the variations in potential of the rail itself.

We can thus see that only a small error in the expression for the current density flowing between the rails and the earth is produced when we give the same value V_o to the potential of the earth at all points.

When it is a question of a network of which one of the points is connected to a good earth point we should evidently assume that the potential of this point is exactly equal to the potential V_o.

When, on the contrary, it is a question of a network not having at any point a direct connection to earth, and having well insulated feeders, we can determine the mean value V_p of the potential of the earth from the following considerations:—

We know that in such a case the sum of the currents leaving the rails towards the earth is equal to the sum of the currents returning to the rails—in other words, the algebraic sum of all the currents leaving the rails (or returning to the rails) is zero.

This condition is as follows :—

$$\int C_M \, (V_M - V_0) \, dl = 0 \qquad \text{.....(7)}$$

The integral being taken over the whole length of the network of rails.

From this we obtain :—

$$V_0 = \frac{\int C_M \, V_M \, dl}{\int C_M \, dl} \qquad \text{.....(8)}$$

In connection with the values to be given to the coefficients of losses C_M, experience has shown that we can assume that these coefficients keep the same value throughout the whole length of a network if the same type of rail is used throughout, and if the rails are installed throughout in the same way. In such a case the coefficients are eliminated from formula (8). When this is not the case, it is convenient to divide up the total network into regions within which we can give these coefficients a uniform value. It is sufficient, however, for the calculation that these coefficients be determined by an approximately constant factor.

We can, for example, adopt the following values for C :—

$C = 1$ for a double track with grooved rails.

$C = 0.7$ for a single track with grooved rails.

$C = 0.1$ for a single track with flanged rails.

Thanks to these circumstances, we can determine for formula (8) a more complete expression.

Consider the section of track (in the sense defined in the Recommendations) or, more precisely, the part of a section of track for which we can give C a uniform value.

Let A and B be the extremities of this part of the section.

L the length of the section.

J the mean value of the total feeder current entering the section.

V_A and V_B, the potential of the points A and B measured with respect to the potential of reference which has already been mentioned.

For this part of the section we obtain integral :—

$$\int_A^B V_M dl$$

But if l is the distance separating the point M from the point A, we have from Ohm's law :—

$$V_M = V_A + r \int_A^M \left(I_A + J\frac{1}{L} \right) dl$$

r representing the resistance of the track, I_A the current flowing in the track at the point A (positive in the direction of B towards A).

We have :—

$$V_M = V_A + rl\, I_A + r\frac{J\, l^2}{L\, 2}$$

In particular :—

$$V_B = V_A + rL\, I_A + r\frac{J\, L^2}{L\, 2}.$$

From which :—

$$\int_A^B V_M\,dl = L\left(V_A + r\,I_A\frac{L}{2} + r\frac{J\,L^2}{L\,6}\right)$$

$$= \frac{L}{2}(V_A + V_B) - \frac{L^2}{12}rJ.$$

In general, even for a rather long section, the term of the second degree in L is negligible. There remains, therefore :—

$$\int_A^B V_M\,dl = \frac{L}{2}(V_A + V_B)$$

and the expression for Vo can be written

$$V_0 = \frac{\sum CL\,(V_A + V_B)}{2\sum CL}$$

the summation being extended over all the sections of the traction network.

When the preceding calculations have been made we can form for each point of the network the difference $V_M - V_0$, and make certain that at no point do these differences exceed the value of 0.8 volt indicated in paragraph 16 of Section B of the Recommendations.

If this is not so, it signifies that the number of return feeders is too small or that the resistances of these feeders are not efficiently arranged; or, further, that the location of the connection points of the feeders to the rails have not been properly chosen.

It is necessary, then, to study as above the configuration of the feeders or of the rails satisfying the given conditions.

APPENDIX II.

TO THE RECOMMENDATIONS CONCERNING THE MEASURES TO BE TAKEN FOR THE PROTECTION OF CABLES AGAINST ELECTROLYTIC CORROSION.

ELECTRICAL MEASUREMENTS IN CONNECTION WITH ELECTROLYTIC CORROSION.

Electrolytic corrosion being due to stray currents which leave the metallic sheaths of cables, it is desirable to measure directly the intensity of the stray currents in the sheaths themselves or in the earth at the points where these currents enter or leave. There are different methods, of which a number are mentioned below, for carrying out these measurements.

On the other hand, stray currents are caused by differences of potential which exist between the rails and the sheath, and whose importance, other things being equal, is greater, the greater the resistance of the track. Consequently, it is desirable, in order to determine the conditions of a tramway network, to proceed to measure the differences of potential and the drop in voltage, and to measure the resistance of the rail joints.

I.—Measurements of the Stray Current Intensity.

A.—In the metallic cable sheath,

B.—In the earth at the point of entering and leaving the metallic cable sheath.

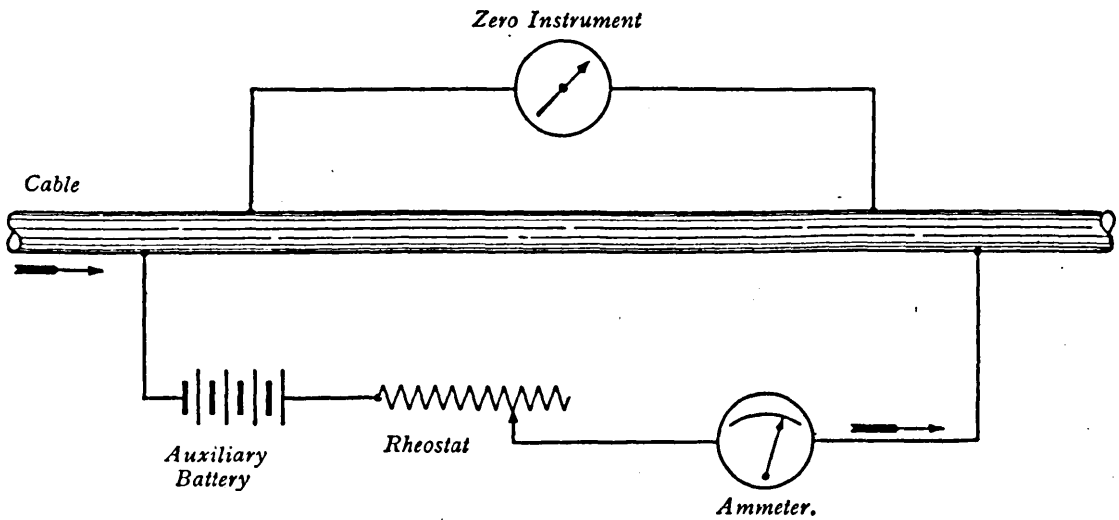
A.—Measurements of the intensity of the stray currents in the cable sheath.

The intensity of the currents which flow in the metallic sheath of a cable can be measured by one of five different methods.

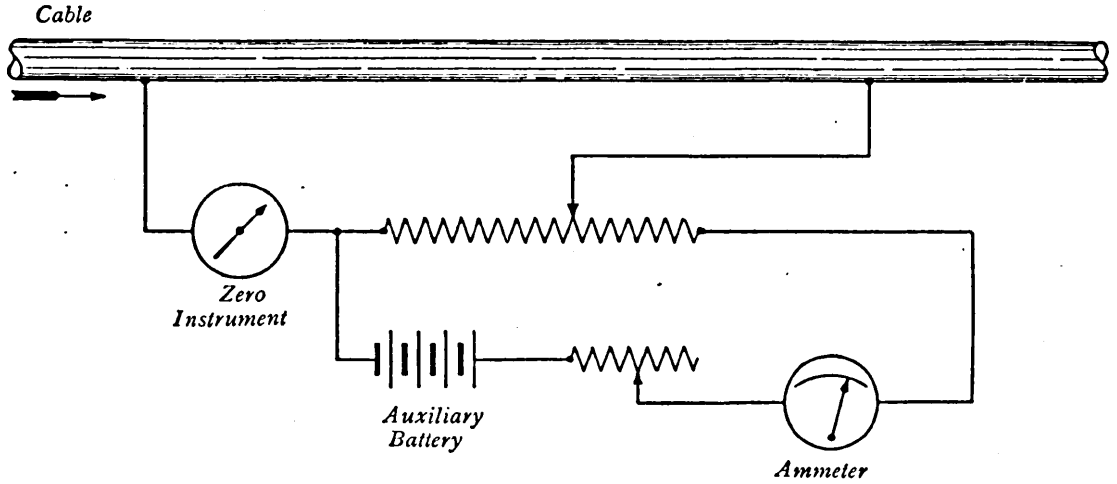
1. The intensity of the stray current flowing in a given length of the sheath can be deduced from the measurement of the difference of potential drop between the two extremities, after having calculated the electric resistance of the given length of sheath from the geometric dimensions and the resistivity of the metal. This method, however, gives rise to error because of the irregularity of the sheath, and because of the damping of the oscillation of the voltmeter shunted by the small resistance of the sheath.

2. In order to measure the stray currents flowing in the metallic sheaths of the cable, this sheath can be interrupted and an ammeter of as small a resistance as possible connected (in practice from $\frac{1}{100}$ to $\frac{1}{10}$ of an ohm).

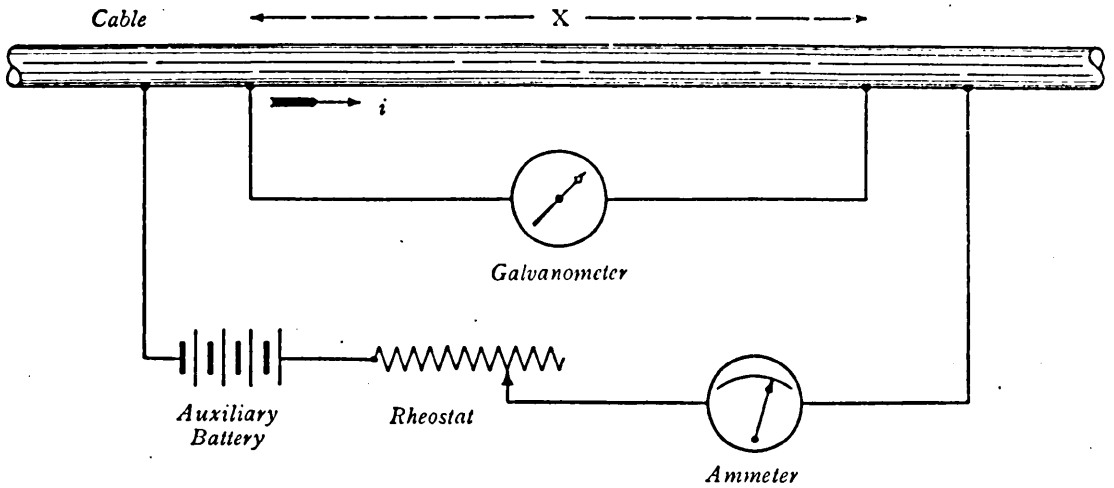
3. In order to avoid breaking the continuity of the metallic sheath of the cable, the current which circulates in this sheath can be compensated by means of an auxiliary battery associated with the rheostat and an ammeter. A sensitive measuring instrument with a short period of oscillation, preferably pivoted (zero instrument), enables it to be determined when this compensation has been properly obtained. The connections are shown below :—



4. Instead of compensating the currents, the voltage along the metallic sheath of the cable can be compensated for according to the following, but it is then necessary to calculate the currents which flow in the sheath, knowing the resistance of the sheath.



5. Finally, the value i of the current flowing in the cable sheath and the resistance X of the sheath can be deduced from two successive readings on a galvanometer connected to the two extremities of the sheath. Arrangements of the connections are shown below, and the theory is as follows. Let i be the intensity of the stray current in the cable sheath at the instant of measurement.



On this current another current i_1 is superposed provided by a battery and measured by an ammeter. The current i_1 is as big as possible and the resistance of the rheostat is so big that the stray current is not shunted appreciably by it. The deflection d is read on the galvanometer. The terminals of the battery are quickly reversed and a new deflection d' is read.

If k denotes a numerical coefficient depending on the galvanometer, then:—

$$(i+i_1)X=kd$$
$$(i-i_1)X=kd'$$

from which is obtained:—

$$i=i_1\frac{d+d'}{d-d'}$$

$$X=k\frac{d-d'}{2i_1}$$

B.—Measurements of the intensity of stray currents in the earth at the point where they enter or leave the cable sheath.

Experience has shown that a current of 0.75 mA per dm^2 of an iron pipe is dangerous from the point of view of corrosion of this pipe. The corresponding value for lead sheaths is in inverse proportion to the electrolytic equivalent of iron and lead. There are three methods for measuring this current.

1. The Haber method, which uses two non-polarisable electrodes of known area buried in the earth at a known distance one from the other and connected to a milliammeter. This method only gives the mean value of the density of the stray currents in the earth, and, further, the use of these plates alters the distribution of the stray currents in the earth.

2. A method at present being studied in Switzerland uses non-polarisable electrodes of small dimensions placed in a small trough which has been constructed in the earth near the cable.

This method allows measurements to be obtained for each position of the electrodes in the trough: (1) the current which circulates between them through the earth, and (2) the specific resistance of the part of the earth between these electrodes. From this a complete investigation can be made of the stray current paths.

3. Another method used in Germany makes use of a metallic electrode connected to the metallic sheath of the cable by a milliammeter. A cylinder is employed for the electrode having a known surface taken from the sheath identical to that of the cable and filled with tar. After waiting for a short time a reading of the milliammeter is taken in order to allow the accumulator, consisting of the electrode and the sheath, to discharge.

II.—Measurements of the Differences of Potential and Drop in Voltage.

In order to measure the difference of potential between a point of the rail and a point in the metallic sheath of the cable a high resistance milli-voltmeter is used and is connected to two contacts. In order to avoid error due to humidity, these contacts are preferably of the same metal as the objects with which they are in contact. The contacts should be as good as possible and have as small a resistance as possible. It is an advantage for the measuring instrument to have a zero at the centre of the scale; the moving part should have a very small oscillation period.

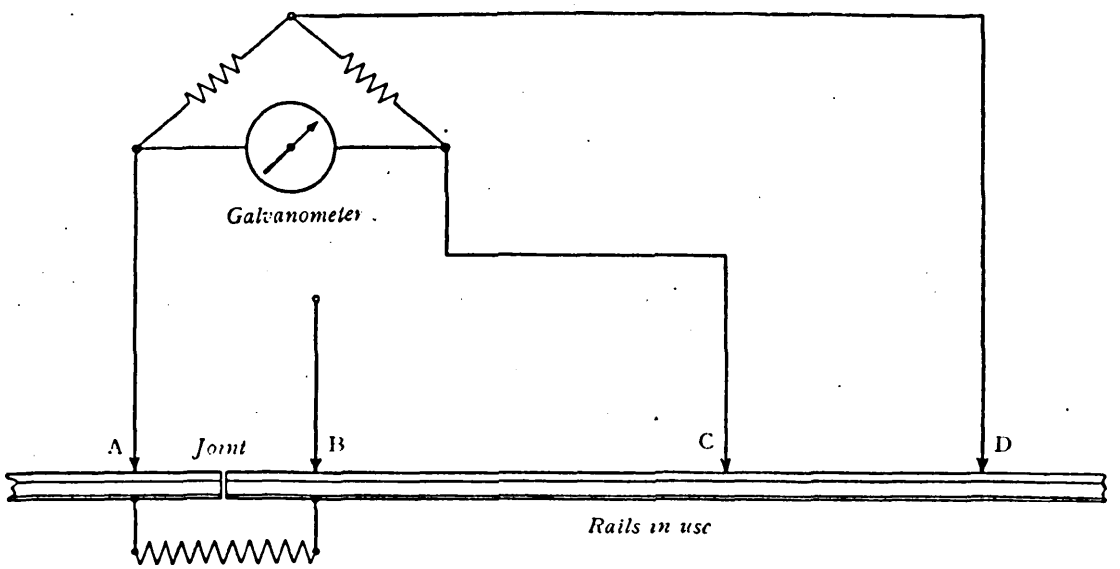
It is desirable in this measurement to take into account the e.m.f. of the local electrolytic couple consisting of the two contacts of different metals.

In order to measure the drop in voltage between two points on the rail similar arrangements are used; no correction is required because the contacts are of similar metal. When the two points and the track between which the drop in voltage is to be measured are sufficiently far apart, use is made of pilot wires, which make it necessary to introduce a correction factor to take into account the resistance of these wires.

III.—Measurements of the Resistance of Rail Joints.

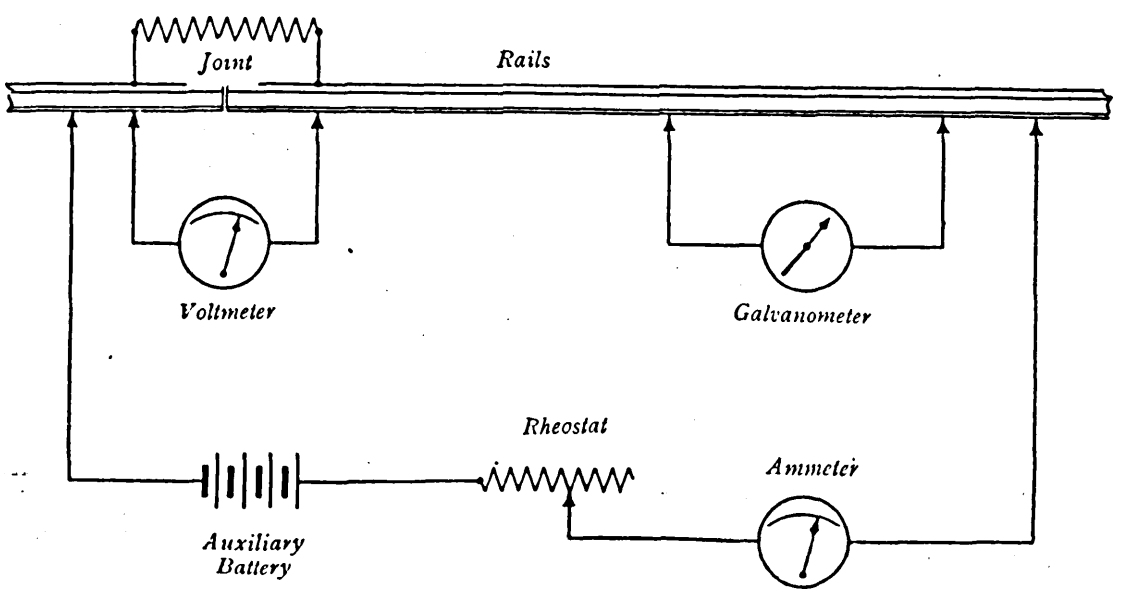
Two methods exist, using respectively, a Wheatstone Bridge, and a comparison method.

1. *Wheatstone Bridge method.*—The resistance $A-B$ of the joint is compared by means of the Wheatstone Bridge with the resistance $B-C$ of a certain length of rail. The difference of potential produced between the points B and D by the traction current which flows in the rail serves as a battery; a galvanometer is used as a zero instrument.



2. *Comparison method.*—The arrangement of the method is as follows :—

The measurement is made when there is no traction current circulating in the rails. An auxiliary battery, a rheostat, a voltmeter and a galvanometer are used. The rheostat is regulated in such a way that the deflection of the galvanometer is constant and well determined. In this case the reading of the voltmeter, in which the scale is calibrated in metres of rails, indicates directly the resistance of the joint as an equivalent length of rail.



VII.—MINUTES OF THE CLOSING MEETING.

The Meeting was opened at 10 a.m., under the presidency of Mr. Lange.

Minutes were read of the Meeting of 17th September, 1931, concerning questions of traffic, exploitation and tariffs.

These Minutes were adopted with the following modification: Page 2, paragraph 2, instead of "these Organisations" read "Broadcasting Companies concerned."

Minutes were read of the Meeting of 17th September, 1931, concerning questions of protection which were adopted without modification.

Minutes were read of the Meeting of 18th September, 1931, concerning questions of transmission. These were adopted without modification.

Minutes were read of the Meeting of 18th September, 1931, of the special Commission on effective transmission.

At the suggestion of Mr. Collet, delegates who may have propositions to make on the question of a more suitable French expression than "transmission effective" as a translation of the English term "effective transmission" were asked to send their suggestions to the Secretary of the C.C.I., the expression "transmission effective" at present being considered provisional.

Minutes were read of the Meeting of the Chief Delegates (18th September, 1931).

At the suggestion of Mr. Gredsted it was decided to add after the 4th paragraph on page 2 of these Minutes, the following phrase:—

> "**Note.**—Certain countries represented at the Plenary Meeting of the C.C.I. in Paris, 1931 (in particular Denmark), were not in favour of this proposition, concerning the classification of the different countries belonging to the C.C.I. for the purpose of the division of expenses incurred by the C.C.I."

On the question of the Meeting of the 6th and 7th Commissions of Rapporteurs, Mr. Fossion, President of these Commissions, made the following remarks:—

Mr. Fossion: The Rapporteurs of the 6th and 7th Commissions are very grateful to the Spanish Administration for having invited them to hold their Meeting at Madrid; but this Meeting is proposed to be held immediately preceding the Plenary Meeting; this will present serious inconvenience. It has been the practice up to the present for the Commissions of Rapporteurs to meet at least two months before the Plenary Meeting, so that Administrations and Operating Companies can study with care, before the Plenary Meeting, the recommendations which have been proposed by these Commissions. This method of procedure has always given the best results. On the other hand, the Rapporteurs are reluctant to leave their Administrations and Companies for a very long time. They prefer not to have to extend from 8 to 10 days the long absence that would be necessitated by their taking part in the Meeting of the Commission and at the Plenary Meeting of the C.C.I. at Madrid. It will be convenient therefore if, in accordance with the arrangements which have been followed previously, the Meeting of the 6th and 7th Commissions of Rapporteurs can take place during the month of May (or June), 1932, preferably in some central town of Europe, in order to reduce as much as possible the distances to be travelled. This is the question that I wish to submit for your approval. I believe it is the wish of all Rapporteurs of the 6th and 7th Commissions.

Mr. Gredsted: As Rapporteur of the 6th and 7th Commissions, I support the proposition made by Mr. Fossion.

The proposition of Mr. Fossion was upheld by the Plenary Meeting, who decided that the Rapporteurs of the 6th and 7th Commissions, on the suggestion of their President, should discuss at an agreed time the date and place to be fixed for the Meeting of their Commissions, in agreement with the Secretary of the C.C.I.

Mr. Lange: With regard to the proposition of the Chief Delegates concerning the Plenary Meeting at Madrid, before the International Telegraph Conference, restricted to questions of traffic, exploitation and tariffs, has anybody any observations to make? As there are no comments I propose that we accept with hearty thanks the invitation of Mr. Hernandez Barroso and express to him our pleasure in visiting his country next year.

Does this Plenary Meeting approve the suggestions made by the Delegation of the United States concerning the classification into two categories of new questions submitted for our study, this suggestion having already been approved by the Chief Delegates?

I note that the American proposition has the approbation of this Meeting. Chief Rapporteurs will therefore be asked to classify into two categories the questions which have been submitted to their Commissions for study by the present Meeting. The Minutes of the Meeting of the Chief Delegates, bearing in mind the remarks made by Mr. Gredsted, are therefore adopted.

We have received several telegrams which I am going to read to you. The first is from Mr. Di Pirro, in reply to the telegram which we sent him at the beginning of the opening Meeting of this Assembly:—

"Very much appreciate your great favour. Please accept my heartfelt thanks and all my wishes for success in your work."

We are deeply moved by the wishes of Mr. Di Pirro and hope that he will be permitted to be amongst us next year.

The second telegram is from Shanghai and is signed by Mr. Frank Gill, Chief Delegate for the Argentine Republic:—

"Best wishes for successful Meeting and regret that I cannot be present."

I am sure that I am interpreting the feelings of the Assembly in expressing the unanimous regrets at the absence of Mr. Gill.

Finally a telegram from Mr. Bartholomew, in reply to one which in the name of the Plenary Meeting was addressed to him at the beginning of the first Meeting dealing with the question of protection.

"Please express to Delegates my appreciation of kindly thoughts conveyed in telegram. My health is now better."

Let us hope for the prompt recovery of Mr. Bartholomew.

I must thank the auditors, Colonel Sir Thomas Purves, Dr. Breisig, and Mr. Di Pirro for their collaboration during the course of the last year. It is necessary to appoint Auditors for the year 1932.

I propose to recommend the mandates of Dr. Breisig and Mr. Di Pirro, but with regard to Colonel Sir Thomas Purves, I very much regret that I cannot make this proposition; you know, in fact, Mr. le Ministre emphasised it the other day, that this is the last time that Colonel Sir Thomas Purves will be amongst us, for he is very soon to retire.

His departure is an irreparable loss to the C.C.I. He was one of the founders of the C.C.I., to which he has always been very closely attached and has contributed very much to its development.

His participation in our work has certainly been of the greatest importance, but he is amongst those whose presence alone has created the prestige of the Assembly; we are indebted to him also for a large share of the atmosphere of cordiality and sympathy at these meetings and which emanated quite naturally from him. Why is it necessary that he, in the best of health and strength, should leave us? His country on many occasions has confirmed his excellent qualities. First of all, he was nominated for the highest position amongst the technical hierarchy of the British Post Office. Then His Majesty the King was pleased to recognise the value of his services by a very honourable distinction. Finally, the Institution of Electrical Engineers has honoured him with their Presidency.

Dear Sir Thomas Purves, after a life so well occupied, you are retiring. Let me say that our affectionate wishes accompany you in your retirement. We hope that you will travel a good deal, that we will

have the pleasure of meeting you often and that we shall be able, each time, to express to you our esteem and affection.

Sir Thomas Purves : M. le Président, Madame, Messieurs, Mr. Lange's very amiable words have not quite come as a surprise to me, for Mr. Valensi warned me before this Meeting what I might expect. I assure you that I am deeply moved by the kindness of these words and by the sentiments that inspired them. It is true that this Plenary Meeting is probably the last Meeting of the C.C.I. at which I shall have the pleasure to be present. For many years (more than 40) in my position as an official of the Government, I have always known more or less exactly where I should be and what I should be doing for the following year ; now I can, so to speak, view this world with a little of the spirit of an adventurer and rejoice in not knowing where I shall be or what I shall be doing in a year's time. There is one thing at least of which I am certain; it is that I shall not have forgotten the good friends of the C.C.I., and all the work that we have done together, always in the most cordial and harmonious atmosphere, devoted to the improvement of international telephone communications, and by this very means to the increase of friendship and good-will of the whole world. The memories of the C.C.I. I shall regard always as something very precious : but I shall not say adieu to people here. As Mr. Lange has suggested, I hope to be able to travel a little, and if I find myself in any spot where I can visit an old friend of the C.C.I. I shall not fail to look him up.

I well remember our first Meeting of the Plenary Technical Committee which took place at Paris in 1923 under the presidency of Mr. Dennery, whose premature death caused us such regret.

I remember also the first Plenary Meeting of the C.C.I in 1924 at the Musée Social, under the presidency of our friend Mr. Milon. One of the best decisions—one could say the masterpiece of this Meeting—was the nomination of our friend Mr. Valensi as the General Secretary, a function that he has fulfilled ever since with so much zeal and success. The Delegates who took part in this first Meeting and are still present at this 8th Plenary Meeting are not very numerous ; but it is true that eminent people have since given to the C.C.I their most invaluable assistance.

From the bottom of my heart I thank you for the extreme good wishes and the amiable indulgence that you have always shown in my regard, and hope that in the future I shall have the pleasure of seeing you again.

Mr. Lange : Messieurs, it is necessary for us to replace Colonel Sir Thomas Purves as one of the auditors ; are there any suggestions to be made to the Meeting on this subject ?

As this is not the case, I propose that the successor to Colonel Sir Thomas Purves as the Chief of the British Delegation to the C.C.I., be asked to take on the duties of auditor for 1932.

Sir Thomas Purves : I will make known this decision to my successor, and I thank the Meeting on his behalf.

Mr. Lange : I will now call upon Mr. Valensi to give some explanation of the documents that have been distributed to the Chief Delegates.

Mr. Valensi : The Chief Delegates have received to-day a *dossier*, about which I am going to give some information.

The *dossier* contains the following :—

I. List of Delegates.
II. Minutes of the Opening Meeting.
III. Questions of general organisation.
IV. Questions of transmission, maintenance and supervision of lines and installations.
V. Questions of traffic, exploitation and tariffs.
VI. Questions of protection.
    1st part—Protection against disturbances.
    2nd part—Protection against corrosion.
VII. List of new questions submitted for study.

The new recommendations of the 8th Plenary Meeting of the C.C.I. or the modifications to previous recommendations which appear in the " Livre Jaune " are shown as additions or changes to corresponding sections of this book.

An inquiry will be made from Administrations and Operating Companies belonging to the C.C.I., asking if they approve the new recommendations (or modifications to previous recommendations) concerning, on the one hand, questions of traffic, exploitation and tariffs, and on the other hand, questions of maintenance, and if they have decided to apply these recommendations (or modifications) from the date fixed by the Plenary Meeting.

Mr. Fossion: Concerning the date from which the new recommendations on traffic, exploitation and tariffs should be applied, I propose this be 1st January, 1932. (Agreed unanimously.)

Mr. Valensi: Following the list of new questions submitted for study (grouped by Commissions of Rapporteurs) in the dossier given to Chief Delegates, there are:—

1. A sheet indicating that the periodic maintenance programme of the principal European telephone circuits, set up by a special Commission during this Meeting, will be communicated to the Administrations of Germany, Austria, Belgium, Denmark, France, Great Britain, Hungary, Italy, Norway, Holland, Sweden, Switzerland and Czechoslovakia, to be reviewed by these Administrations before being printed, the date of application of this programme being 1st January, 1932.

2. A sheet concerning " the list of emergency routes in the European telephone service " which has been drawn up by a special Commission during this Meeting; the text of this list will be sent shortly to Administrations and Operating Companies in Europe to be reviewed by these Administrations before being printed, the date when this list will be put into force being 1st January 1932.

Delegates are asked to be good enough to indicate to the Secretary of the C.C.I. any minor errors which are found in this dossier and to excuse these errors since the documents have been hurriedly prepared.

Mr. Lange: It is necessary now to appoint the Commission of Rapporteurs. I ask this meeting to indicate the Administrations and Operating Companies which should appoint the Rapporteurs for the various Commissions.

Seven Commissions of Rapporteurs were appointed.

FIRST COMMISSION OF RAPPORTEURS.

Questions relating to the Protection of Telephone Lines against the disturbing influence of Power Installations.

1. Questions submitted for study to the 1st C.R. of the C.C.I.

Question 1. (*See* previous question No. 1 of the 1st C.R., 1930.)

(*a*) Examination of the permissible limits of disturbing voltage and current from direct current traction installations.

(*b*) Measures to be adopted in the case of parallelism between international telephone lines and direct current traction lines.

Note.—In the study of this question consideration should be given to the experience gained by the 1st and 2nd Committees of the 1st Section of the C.M.I.

Question 2. (*See* previous question No. 2 of the 1st C.R., 1930.)

(*a*) What should be the permissible reduction in articulation in telephone circuits due to the noise induced by electric power installations ?

(*b*) What is the value of the noise voltage corresponding to this reduction in articulation ?

Note.—Part (*a*) of this question should first be studied by the 3rd and 5th Commissions of Rapporteurs, who should submit the result of their study to the 1st Commission.

Part (*a*) of this question is of an economic nature rather than technical. With regard to the definition of the reduction of articulation, it is generally admitted that the ideal reduction of articulation should be considered; as an indication it has been proposed to allow a reduction of articulation whose numerical value is at the most equal to 5 per cent.

Part (*b*) should first be studied by the 4th Commission of Rapporteurs who should submit the result of their study to the 1st Commission.

Question 3. (*See* previous question No. 3 of the 1st C.R., 1930.)

The effect of earthing the neutral point of power installations on the importance of noise induced in adjacent telephone lines.

Note.—When studying this question, consideration should be given to the tests by the 3rd Committee of the 1st Section of the C.M.I., and especially to the tests carried out on the new high-tension network in Great Britain.

Question 4. (*See* previous question No. 5 of the 1st C.R., 1930.)

(*a*) Does the new table, showing the protection devices used in various countries, set up by the C.C.I. in 1930 and revised in 1931 in accordance with information supplied by Administrations and Operating Companies belonging to the C.C.I., represent exactly and completely the actual condition of affairs, not only from the point of view of the schematics, but also as regards the characteristics of the various components (fuses, lightning protectors and heat coils) ?

(*b*) The realisation of a protective device conforming to the general conditions contained in the recommendation of the Plenary Meeting of Paris, 1931, entitled: "Conditions which should be fulfilled by an ideal device to protect against atmospheric discharges and against induction from and contact with power lines."

Question 5. (*See* previous question No. 6 of the 1st C.R., 1930.)

How should the "Guiding Principles" be supplemented with respect to the protection of telephone lines against the disturbing influence of power installations, more especially with regard to the calculation of the noise voltage due to the upper harmonics of direct current installations ?

Note 1.—In the study of this question account should be taken of the experience of the 1st, 2nd, 5th and 8th Committees of the 1st Section of the C.M.I.

Notes.—To study this problem it is necessary to know
(*a*) the disturbing voltage of the sources of direct current.
(*b*) the coefficient of mutual induction.
(*c*) the compensating effect of the rail current and the cable sheath.

The data that is actually available on this question has been obtained with the Osborne device for the measurement of the factor of telephonic disturbance. It will be advisable therefore to take a number of measurements with a new device having a filtering network identical with that of the apparatus for measuring objectively the noise voltage, as recommended by the C.C.I.

The C.M.I. has received a detailed report from Messrs. Zastrow and Wild on the compensating effect of the sheath current. This report which is entitled: "Protection factor of telephone cable sheaths" will shortly be sent to Administrations and Operating Companies of the C.C.I.

Question 6. (*See* previous question No. 8 of the 1st C.R., 1930.)

Calculation of the coefficient of exposure to danger and the induced noise voltage under the influence of the electric field at crossings of high tension and telephone lines.

Note.—In the study of this question, consideration should be given to the experiments of the 10th Committee of the first Section of the C.M.I.

Question 7. (*See* previous question No. 9 of the 1st C.R., 1930.)

What is the relation between the value of the noise voltage and the equivalent voltage at the terminals of a receiver that can be calculated, knowing the induced voltage and the degree of unbalance of a circuit with a localised unbalance ?

Question 8. (*See* previous question No. 10 of the 1st C.R., 1930.)

Comparative study, by exchange of apparatus between Administrations interested, of various protective apparatus against acoustic shocks.

Note.—In the study of this question the experiments made by the 9th Committee of the 1st Section of the C.M.I. should be taken as a basis.

Questions 1, 2, 3, 5, 6 and 8 above belong to class A (questions for which it is important to have an international agreement and to provide a standard method of application, either universally or for the European network).

Questions 4 and 7 above belong to class B (questions of an informative nature, and for which an international agreement is not essential).

11. Questions submitted for study by the C.C.I.T., Berne, 1931.

The following list of questions, which have been submitted for study by the C.C.I.T. to its 6th Commission, or which the C.C.I.T. has asked the C.M.I. to study, are only included here as a record, the documents on these subjects probably being of interest to members of the 1st C.R.

1. Questions to be studied by the 6th Commission of the C.C.I.T.

Question VI. (1) What may be the disturbing effect of parasitic currents, which occur when a power line is subject to transient phenomena (voltage switched on, disconnection, short circuit on the line, start of an electric train, etc.) ?

(2) How should one calculate the effects of induction produced when a non-section contact line is fed by several sub-stations working in parallel ?

2. Questions to be studied by the C.M.I.

Third Committee of the C.M.I.

Under what circumstances is there any danger of trouble affecting the operation of a telegraph line in close proximity to a power line :—

(*a*) with the neutral directly earthed ?
(*b*) with the neutral earthed through a Petersen coil ?
(*c*) with the neutral earthed through a resistance ?
(*d*) with the neutral isolated ?

Fifth Committee of the C.M.I.

The C.C.I.T. is specially interested in the determination of induced voltages on telegraph lines, as a result of the variation in the intensity of the traction current at the moment of the starting and during operation of the machines. It will be desirable therefore for experiments to be made on this subject.

Eighth Committee of the C.M.I.

What reduction in the effects of magnetic induction on cable circuits is brought about by the circulation of induced currents in the sheath ?

To what extent does this compensating action depend upon the specification of the lead sheath and armouring, the frequency of the inducing current, the installation conditions of the cable (existence of good earth points) and its distance from the inducing line ?

The C.C.I.T. are mainly interested in industrial frequencies.

Tenth Committee of the C.M.I.

The C.C.I.T. is especially interested in the determination of the influence on a single wire circuit of a power line under normal service conditions, when these two lines cross. How does this influence vary with the angle of crossing, length of line exposed and service voltage ?

Members of the First Commission.

The following countries to appoint Rapporteurs :—

GERMANY : Dr. Jäger (*Chief Rapporteur*) and Dr. Klewe.
AUSTRIA : Mr. H. Pfeuffer.
FRANCE : Messrs. Rochas and Collet.
GREAT BRITAIN : Mr. S. C. Bartholomew.
ITALY :
MEXICO : Mr. H. Pleijel.
RUMANIA : Mr. B. H. MacCurdy.
SWEDEN : Mr. G. E. Swedenborg.
CZECHOSLOVAKIA : Mr. R. Rod.

SECOND COMMISSION OF RAPPORTEURS.

Questions concerning protection of telephone cables against electrolytic corrosion and chemical action.

Is it possible to replace the lead sheath of a cable with a sheath of benzyl-cellulose or a mixture of ethyl and benzyl-cellulose, these two materials being good dielectrics, resisting to a great extent the influence of ground water and organic acids, and, for a thickness of 1.5 mm, being able to withstand six successive bends at 90° ? (A cable with such a sheath has three windings of paper covered with a winding of metallised paper.)

This question belongs to class B (questions of an informative nature and for which an international agreement is not essential).

Members of the Second Commission.

The following countries to appoint Rapporteurs :—

GERMANY : Dr. Breisig (*Chief Rapporteur*).
BELGIUM : Mr. Parfondry.
FRANCE : Mr. Collet.
GREAT BRITAIN : Mr. S. C. Bartholomew.
ITALY :
SWEDEN : Mr. A. V. A. Holmgren.

THIRD COMMISSION OF RAPPORTEURS.

Questions concerning Transmission and Maintenance.

Question 1.

For the purpose of international standardisation, what should be the characteristics of automatic level recorders (hypsomètres enregistreurs), which should rapidly record the state of the circuits from the point of view of the transmission of different frequencies ?

Note 1.—The use of these automatic level recorders has already been recommended by the C.C.I. (*see* p. 126).

Note 2.—Reference (*a*) attached note entitled "Note on the use of automatic level recorders" (Appendix I to question 1 of the 3rd C.R.). (*b*) "Information relating to the use of automatic level recorders for measurements made on circuits relaying radio-broadcast transmissions" (Appendix II to question 1 of the 3rd C.R.).

Note 3.—The Plenary Meeting of Paris, considering that it is very desirable to introduce automatic level recorders as soon as possible on international circuits, that for this purpose it is necessary to fix certain essential characteristics of these recorders, that the system presented at Prague in June, 1931, gives, with certain modifications, satisfactory results, that, however, along with the development of this apparatus, it will be necessary to introduce modifications from time to time, has decided to fix the following characteristics for automatic level recorders :—

(*a*) The band of frequencies.
(*b*) The scale of frequency against time.
(*c*) The duration of transmission of the measuring frequency.
(*d*) The method of indicating the frequencies at the receiving station.
(*e*) The impedance and power of the generator.

The characteristics have been fixed, provisionally, as follows :—

(*a*) Band of frequencies : 30 to 10 000 p : s.
(*b*) Scale of frequency and time :

30—100 p : s linear scale.
100—10 000 p : s logarithmic scale.

(*See* figure below.)

these scales being continuous by going from the low frequencies to the high frequencies.

(*c*) Duration of transmission :

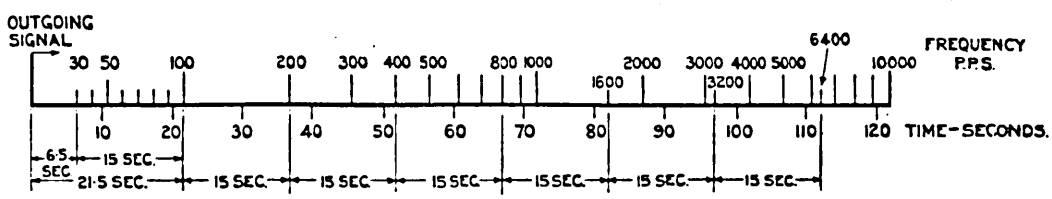
of an octave in the band 100—10 000 p : s —15 secs.
in the band 30—100 p : s —21·6 secs.

(*d*) Method of identifying the frequencies at the receiving station : a signal is sent from the transmitting station 6·5 secs. before commencing to send the line frequency 30 p : s.

The characteristics of this signal are :—

frequency	1 300 p : s.
duration	1.5 secs.
output voltage	0.775 volt.

(*e*) Impedance of generator 600 ohms
Power furnished to 600 ohms : 1 mW.



SCALE OF FREQUENCY AND TIME FOR AUTOMATIC LEVEL RECORDERS.

Question 2. (*See* previous question No. 2 of 3rd and 4th C.Rs., 1930.)

On the basis of the results collected by the 4th C.R. (see Question No. 2 to be studied by the 4th C.R.), for an international telephone circuit under ordinary working conditions, what are the values in transmission units of :—

(*a*) Reduction of transmission quality due to a certain limitation of the band of frequencies effectively transmitted ?

(*b*) Reduction of transmission quality due to noise of a certain intensity ?

Question 3.

In the case where two-wire repeaters are inserted at fixed intermediate points on long aerial or mixed circuits.

(1) What is the most favourable gain for these repeaters in service?

(2) What are the possible variations in stability due to atmospheric influences (temperature, rain, etc.)?

(3) How is it possible to obtain the most favourable regulation of the balancing networks?

Note 1.—In the European telephone network there are still long aerial or mixed circuits, where it is necessary to have repeaters installed at a fixed position (as distinct from cord circuit repeaters at the extremities). The stability of these lines and repeaters depends, particularly, on atmospheric variations (humidity, rain, temperature variations, etc.); this leads to the gain being varied during service. It will be useful to obtain results of practical tests concerning the measurement of variations in stability, the most favourable regulation of phantom circuits and the maximum value of gain obtainable in service.

Note 2.—A preliminary reply to this question will be drawn up by the Chief Rapporteur of the 3rd C.R. on the basis of previous C.C.I. recommendations, and in accordance with information already collected on this matter.

Question 4.

In Appendix B.d. 2, No. 4, "Essential clauses for a typical specification for the supply of a complete telephone cable between terminal exchanges, including repeater stations, assuming that the cable is ordered from one contractor, who assumes responsibility for overall results" (Part 3 Relative Levels) (*see* p. 181 above) is it advisable to complete this recommendation by stating that the power level at any point of the circuit should not be greater than +1·1 népers, or +9·5 decibels, nor less than −3 népers, or −26 decibels?

Note.—This recommendation has already appeared in Appendix B.d. 2, No. 4 (p. 293 of the "Green Book"—C.C.I. 1928, English translation, p. 223). The new edition, conforming to the recommendations of Brussels 1931 ("Livre Jaune," p. 435) merely contains recommendations concerning permissible levels at the output of frontier repeaters. It seems desirable to revert to the original recommendation referring to any point of the circuit the text of which was "In the case of 4-wire circuits the transmission level at any point on a circuit contracted for must be within +1·1 népers or +9·5 decibels and −3·0 népers or −26 decibels. In the case of 2-wire circuits it is desirable to maintain the level between the limits +0·6 néper or +5·2 decibels and −1·6 népers or −14 decibels.

Question 5.

Is it desirable to set up a general programme of international telephone connections, which will include a plan of international telephone centres and alternative routes?

In the affirmative:—

(*a*) What should be the transmission characteristics, total equivalent, time of propagation, transient period, crosstalk, noise, etc., for the longest section of line and for each of the different sections, considered separately?

(*b*) What measures should be taken to reduce the intervention of operating personnel on questions which influence the general transmission results?

Note.—In the study of the last part of this question the 6th C.R. should be represented at the meeting of the 3rd C.R.

Question 6.

What measures should be taken to avoid the use of numerous echo suppressors on a connection using several interconnected circuits and to be certain that the hang-over time is suitably adjusted, with the time of propagation on the overall circuit?

Question 7.

Allowing for the continued improvement on lines and subscribers' apparatus, should not future long-distance circuits be arranged to transmit a band of frequencies from 300—2 750 p : s?

Note.—See question 2 of the 3rd C.R. and question 2 of the 4th C.R.

Question 8.

What methods and measuring apparatus should be recommended for measurements on lines and apparatus for high frequency carrier current telephony?

Question 9. (Previous question No. 9 of the 3rd C.R., 1930.)

What are the most satisfactory arrangements for the construction of screens for circuits used for the transmission of music, relative to the maximum resistance of the screen, the crosstalk effect of the screen, the influence of the screen on the mutual capacity of the screened circuit ?

Question 10.

Allowing for the extension of international telephone service and the increasing use of principal circuits for connection with radio links to U.S.A., South America, etc., is it desirable to reserve, in future cables, a certain number of circuits with a high speed of propagation as, for example, 1.3 mm 4-wire circuits, with a lighter loading than that at present used with 0.9 mm 4-wire circuits ?

Question 11. (*See* previous question No. 11 of the 3rd C.R., 1930.)

What is the permissible value of the echo attenuation (or the active reflection loss) for a whole 2-wire international circuit, or for a repeater section ?

Note.—This question consists of two parts :

(*a*) The part concerning the line itself.

(*b*) The part concerning the adaptation of the line to the repeaters.

On this last point, it is necessary to consider the desirability, when specifying the requirements for the adaptation between the impedance of a 2-wire repeater and the impedance of the circuit to which it is connected (Appendix B.c.4, No. 1, p. 148, under " Impedance,") of distinguishing :

(1) For one frequency, the case of light loaded and medium-heavy loaded circuits.

(2) For one circuit, the case of average and limiting frequencies.

In the affirmative, what are the maximum permissible values, in the different cases, for the coefficient of reflection at the extremity of a repeater section of a 2-wire circuit ?

Question 12.

Allowable limits for transient phenomena on circuits used for relaying radio-broadcast transmissions.

Note.—Can the values of 10 millisecs. and 80 millisecs. be allowed as maximum values on the one hand, for the difference between the time of propagation at 6 400 p : s and 800 p : s and, on the other hand, for the difference at 50 p : s and 800 p : s ?

Question 13. (Previous questions Nos. 13 and 14 of the 3rd C.R., 1930.)

(*a*) Can the coefficient of non-linear distortion be defined exactly ?

(*b*) What method should be used to measure the coefficient of non-linear distortion in an entire system or in a part of the system excluding the subscribers' apparatus ?

(*c*) What limits should be specified for the coefficient of non-linear distortion of an entire system or of a part of this system (in the case of a commercial telephone circuit and the case of a circuit relaying radio-broadcast transmissions) ?

Note 1.—In the case of a circuit relaying radio-broadcast transmissions the Broadcasting Companies have pointed out that the effects of non-linear distortion are perceptible in radio-broadcast transmissions when the attenuation of this distortion is 3·2 népers.

Note 2.—The study of part (*a*) of this question is of interest to both the 3rd and 4th C.R.s.

The provisional definition of non-linear distortion proposed by the C.C.I. (Paris, 1931) is as follows :—

" The coefficient of non-linear distortion is the ratio of the effective value of all the harmonics introduced by non-linear distortion to the effective value of the fundamental."

Note 3.—When a complete or partial system presents a non-linear characteristic, the curvature of this characteristic has different effects, the most important being the following :—

When a sinusoidal voltage is applied at the input of a system or the part of a system considered, the non-linear distortion causes certain harmonics (2nd harmonics predominating in the case of the ordinary repeater, 3rd harmonics in the case of push-pull repeaters) ; the amplitude of these harmonics in relation to the fundamental is not the only consideration ; the interval of time between the reception of the fundamental and the harmonics is of equal importance.

Further, the non-linear distortion results in a variation of the equivalent of the complete or partial system considered, with the amplitude of the voltage applied at the input, and this phenomenon presents, in the case considered, another aspect of the question.

In the case where two sinusoidal voltages of different frequencies are applied at the input of the system or partial system considered, the non-linear distortion causes, not only the appearance of harmonics of the two frequencies, but also the production of differential sounds (Helmholtz). Further, if the level of one of the input voltages varies, it may result in variations in the equivalent of the system for the other frequency.

It will be interesting to investigate the possibility of preparing a universal standard in order to be able to judge the importance of non-linear distortion of a complete or partial system in relation to the curvatures of the characteristics between two electrical variables of the complete or partial system.

In the affirmative, it will be useful to find out the relation between this standard and the importance of the different effects stated; these effects are particularly evidenced by the following measurements.

Variation of equivalent as a function of the level for a certain frequency.

Coefficient of non-linear distortion (that is the ratio between the amplitude of the predominating harmonic and the fundamental).

Relation between the variation of amplitude of a sinusoidal current of a particular frequency and the equivalent that the system offers to another frequency simultaneously applied.

The amplitude of a differential sound obtained at the extremity of the system when two sinusoidal voltages of different frequencies and definite amplitudes are applied at the output.

Question 14. (Proposed by the 6th C.R. at its Meeting in London, April, 1931.)

Is it always necessary to have a delay of half an hour between the moment when a circuit is turned over to the Broadcasting Company and the time the radio-broadcast transmission commences, *see* pp. 2 and 4, and could not this be reduced; the maintenance instructions recommended by the C.C.I. in the case of radio-broadcast transmissions being then modified accordingly?

Note.—This question will be first submitted to the International Broadcast Union; if this organisation agrees to this delay being reduced, it will be satisfactory to modify accordingly the instructions for the setting up and maintenance of international circuits.

Question 15. (Previous Question No. 15 of the 3rd C.R. 1930.)

What should be the maximum permissible value for the time of propagation of a very long international telephone circuit, or, in other words, what should be the minimum speed of propagation?

Note.—*See* Appendix III (concerning the new question No. 15 of the 3rd C.R.).

Question 16.

Revision of "Guiding Principles" as a help toward the establishment of "essential clauses of a specification for voice frequency ringers" (Appendix B.c. 4, No. 4), particularly with reference to the time of operation of the receiving apparatus.

Note.—In studying this question it will be well to compare the new arrangements of signalling provided recently in various countries.

Question 17.

Are there any economical arrangements for compensating the effect of temperature variation on the equivalent of a repeatered circuit?

Note.—At present, such arrangements have been installed on circuits used for radio-broadcast transmissions; their cost is too high for them to be used on ordinary telephone circuits; also on those latter circuits the effect of temperature variations is compensated from time to time by modifying the anti-distortion arrangement of the repeaters.

Question 18.

Considering the disturbances to side or phantom circuits in the outer layer of a cable ("Livre Jaune," pages 733-738; English Edition, pages 432-434), the unbalance to earth of the circuit is characterised by the difference of the capacities that each of the elements of the circuit presents, not only to the sheath and to all the other conductors, but also to the sheath alone. Accordingly, it is advisable to study if it is necessary to complete the "permissible values of 'side to earth' and 'phantom to earth' capacity unbalances between circuits of the same phantom group" (Appendix B.d. 2, Nos. 1 and 2) by indicating the permissible values for the differences between the capacities to the sheath alone, either for all the layers in the cable or merely for the outer layer.

Question 19.

"Guiding Principles" for the establishment of a specification for the supply of valves for telephone repeaters.

Question 20.

The constitution of a cable circuit used for harmonic telegraphy differs a little from that of a 4-wire telephone circuit. In the " General rules for the make-up of transmission systems " (" Livre Jaune," page 244; English Edition, page 140), the instructions for the maintenance of international circuits (page 110 and onwards); and the essential clauses for a typical specification for the supply of a complete telephone system (Appendix B.d.2, No. 4). How should these be completed to include the use of certain circuits for harmonic telegraphy ?

Note.—This question should be studied in collaboration with the C.C.I.T.

Question 21.

(*a*) Is it possible always to reduce the reference equivalent of a 4-wire circuit to 0.8 néper or 7 decibels and that of a 2-wire circuit to 1 néper or 9 decibels ?

(*b*) Will it be possible to recommend in future that the reference equivalent of the combination of international circuits in a transit connection should never exceed the limit fixed for the reference equivalent of a single circuit ?

(*c*) What are the values of minimum net power loss to which each type of inter-urban telephone circuit can be regulated so as not to exceed the limits allowed for echo, reflection loss, crosstalk and other characteristics ?

Note.—In studying this question the 5th C.R. will collaborate with the 3rd C.R. as regards the circuits for radio-telephony.

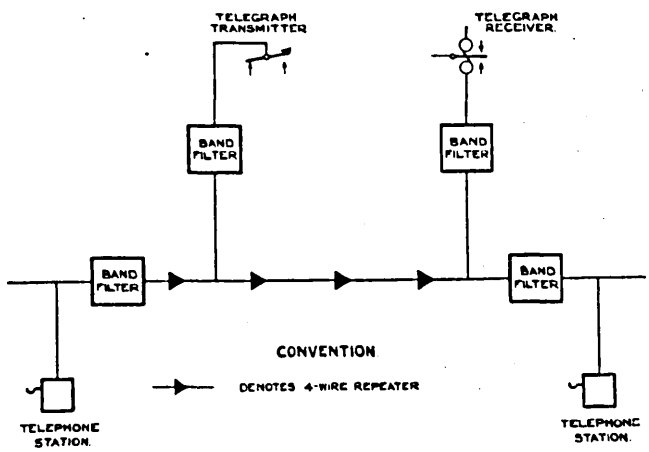
Question 22. (Previous question No. 22 of the 3rd C.R. 1930.)

Is it possible to use, for telegraph purposes, the band of frequencies between the highest telephone frequency transmitted and the cut-off frequency of a cable telephone circuit (ultra-acoustic telegraphy) ?

Note 1.—This question is of interest both to the C C.I. and the C.C.I.T.

Note 2.—It is possible, in principle, to employ a telephone circuit for telegraph connections by making use of the band of frequencies between the maximum frequency for telephone purposes and the maximum frequency transmitted by the repeaters using, for example, the scheme shown below. Certain conditions, however, must be specified.

*It is necessary to leave free, for telephone purposes, a band of frequencies up to 3 000 p : s, and further, it is advisable, where the filters used have not sufficiently rigid characteristics, to take



FREQUENCY OF TELEGRAPH TRANSMISSION f = 2900 P.P.S.

care that, between the frequency of 3 000 p : s and the telegraph frequency, there is an unused band of suitable width. It will be useful to make articulation tests to determine whether the telegraph transmission interferes with the quality of the telephone communication and if there is not a case for fixing, in particular, a permissible maximum limit for the value of the telegraph currents.

* The text of this paragraph should be sent to the C.C.I.T.

It is also to be pointed out that in utilising a long-distance circuit simultaneously for telephony and telegraphy, certain technical difficulties arise in the operation of these circuits. Firstly, the greater number of long-distance circuits are equipped with echo suppressors ; the corresponding repeaters should therefore be connected with special branching repeaters. The listening arrangements in the stations must be protected against the telegraph currents ; similarly, precautions must be taken to protect the telegraph against the telephone circuit.

Finally, tests should be made of the difficulties in controlling repeaters without disturbing the telegraph circuit.

Questions 1, 2, 4, 5, 6, 7, 10, 11, 12, 13, 15, 20, 21 and 22 above belong to class A (questions for which it is important to have an international agreement and to provide a standard method of application, either universally or for the European network).

Questions 3, 8, 9, 14, 16, 17, 18 and 19 above belong to class B (questions of an informative nature and for which an international agreement is not essential).

Members of the Third Commission.

The following countries to appoint Rapporteurs :—

GERMANY : Mr. Höpfner (*Chief Rapporteur*).
BELGIUM : Mr. Haemers.
CUBA : Mr. P. E. Erikson.
DENMARK : Mr. N. E. Holmblad.
SPAIN : Mr. J. M. Clara.
U.S.A. : Mr. H. E. Shreeve.
FRANCE : Messrs. Aguillon and Belus.
GREAT BRITAIN : Messrs. C. Robinson, C. A. Taylor and G. Manning.
ITALY :
MEXICO : Mr. M. Vos.
HOLLAND : Messrs. H. J. Boetje and A. H. de Voogt.
ROUMANIA : Mr. B. H. MacCurdy.
SWEDEN : Mr. A. V. A. Holmgren.
SWITZERLAND : Dr. H. Keller.
CZECHOSLOVAKIA : Mr. J. Michálek.
U.S.S.R. : Mr. O. Kaulchin.

Note.—The Permanent Sub-Commission on Maintenance, constituted as part of the 3rd C.R., which deals with all questions concerning the application of the C.C.I. instructions for the establishment and maintenance of international telephone circuits has as its chairman Mr. Höpfner (Germany) and as other members : Mr. Winzheimer and Mr. Richter (Germany), Mr. Parmentier (France), Mr. Chamney (Great Britain), Mr. Visser (Holland), Mr. Nordström (Sweden) and Dr. Keller (Switzerland).

FOURTH COMMISSION OF RAPPORTEURS.

Questions concerning The Standard Reference Systems.

Question 1.

(*a*) Is it possible to characterise voice volume by means of a power (acoustic or electrical) measured in C.G.S. units (for example, the average power of a logatome or a particular vocal sound during a determined interval of time) ?

(*b*) What is the ratio between the average voice volume used in the course of a telephone conversation and the reference voice volume ?

Note 1.—Reference—Appendices IV and V above entitled " Speech Power and its Measurement " by Sivian (*Bell System Technical Journal*, October, 1929) and a memorandum of the A. T. & T. Co., dated 4th September, 1931.

Note 2.—Although it is not considered necessary to specify at the moment a maximum value of power (in alternating current at the average voice frequency) corresponding to the voice volume transmitted in commercial telephone conversations (particularly on account of the large variations of the maximum power of the human voice during the course of conversation), the Plenary Meeting of the C.C.I. at Paris, 1931, has provisionally recommended the value of 5 milliwatts (at 800 p : s) as the value of the power which, applied at the relative zero level, should be transmitted without non-linear distortion. Such a value is in effect necessary for the establishment of essential clauses of typical specifications for the supply of equipment on telephone circuits (particularly repeaters). On the basis of this value of 5 milliwatts (at zero level) the following maximum values of power P that can be obtained at the output of a repeater without causing interference due to non-linear distortion (coefficient of non-linear distortion less than 5 per cent.), have been provisionally determined.

Values of P.	*Milliwatts.*
Repeaters for 2-wire circuits in cable	20
Repeaters for 4-wire circuits in cable	50
Repeaters for 2-wire circuits in open wire	20
Repeaters for voice frequency telegraph connections (harmonic telegraphy)	50

Question 2. (*See* previous question No. 2 of the 3rd and 4th C.R., 1930.)

What are the results of tests made to evaluate in units of transmission, for an international telephone circuit under normal operating conditions.

(*a*) The reduction of quality due to the limitation of the band of frequencies effectively transmitted ?

(*b*) The reduction of quality due to noise ?

Note 1.—The results of these tests will be used by the 3rd C.R. for the study of their question No. 2.

Note 2.—It is desirable for Administrations and Operating Companies to continue tests already in hand in accordance with the indications in Appendix VI below, and its two supplements.

The conditions under which the tests have been carried out in America and Germany (the results of which are shown graphically in Figs. 1-4 of Appendix VI) are indicated in the first supplement to this Appendix.

Question 3. (*See* previous question No. 3 of the 4th C.R., 1930.)

In order to facilitate the standardisation of volume indicators and of peak indicators by comparison with the " SFERT " volume indicator, would it not be an advantage to standardise in telephonometric tests, a certain sequence of logatomes instead of different phrases actually utilised in different countries?

Question 4.

Can the coefficient of non-linear distortion be exactly defined, and what are the best methods to be used for measuring this non-linear distortion in a particular case of telephone subscriber's apparatus ? (*See* also question No. 13 of the 3rd C.R.)

Note 1.—The influence of non-linear distortion affects, on the one hand, voice volume and on the other hand, articulation.

As regards the effect on voice volume, the method of measurement actually used takes this into account entirely.

As to the effect on articulation, the method of measuring articulation applied in the " SFERT " Laboratories took this into account up to a certain point only.

However, it is necessary to define exactly the coefficient of non-linear distortion and to study the best methods of measuring this distortion.

Note 2.—A similar question is included under No. 13 of the List of Questions to be studied by the 3rd C.R. Collaboration by the 3rd and 4th C.R.s on this subject is desirable.

Question 5. (Previous question No. 5 of the 4th C.R., 1930.)

Is it possible, in telephonometric tests to replace the human voice by phonograph discs or by a receiver supplied with a combination of frequencies ?

Question 6.

What are the most appropriate methods of determining the transmission characteristics of microphones and receivers ?

Question 7.

What are the most appropriate methods of determining the value of side tone (Kopplung) defined as the reference equivalent of the system consisting of the microphone and receiver of the same subscriber's set under normal conditions of battery supply ?

Question 8. (Previous question No. 8 of the 4th C.R., 1930.)

What is the best system to be utilised to standardise the articulation testing crews of different countries ?

Note—Before being able to reply to this question it is necessary to make various tests of articulation with different testing crews and on well-defined circuits. As it is difficult to obtain on commercial circuits testing conditions which are invariable and well defined, the C.C.I. recommends tests being made in the following manner :—

1. Articulation Tests will be carried out on the following circuits :—

Serial No. of Testing Circuits.	Description of apparatus making up these Circuits.	Attenuation of the distortionless artificial line.	Type of filter used.	Frequency for which the effective attenuation of the filter on 600 ohms is equal to 1·0 néper or 8·7 db.	Frequency for which the effective attenuation of the filter on 600 ohms is equal to 3·0 népers or 26 db.	Corresponding value of the ideal articulation for the characteristic bands of speech. Bi.
				p : s	p : s	
1	" SFERT " without distortion	3·5 népers or 30 db.	No Filter	—	—	—
2	" " "	3·5 " " 30 "	Low Pass	1 900	2 100	0·64
3	" "	3·5 " " 30 "	High Pass	1 480	1 420	—
4	" " "	3·5 " " 30 "	High Pass	900	840	—
5	" " "	3·5 " " 30 "	Low Pass	1 520	1 620	—
6	" " "	3·5 " " 30 "	Low Pass	900	960	—
7	" " "	3·5 " " 30 "	Band Pass	{ 900 / 1 520	840 / 1 620 }	—
8	" SFERT " with distortion in the sending and receiving system.	3·5 " " 30 "	No Filter	—	—	0·46
9	" "	3·5 " " 30 "	Low Pass	1 900	2 100	—
10	" "	6·3 " " 55 "	Low Pass	1 900	2 100	—

Questions 1, 2, 3, 7, 8, 9, 10 and 11 above belong to Class A.

Questions 4, 5 and 6 above belong to Class B.

2. The following corrections will be applied to results obtained :—

(*a*) Correction corresponding to the method described in Appendices B_1 and B_2 (*see* p. 46) of the Recommendations of the C.C.I. concerning articulation measurements, using however low pass and high pass filters shown above in order to determine the coefficient of experience (Z) of the testing crew and by using the curve showing the values of the ratio between B and D in Appendix B_1 mentioned above.

(*b*) Correction corresponding to the method shown in Appendix C of the Recommendations of the C.C.I. concerning articulation measurements which contain all the experimental data actually available.

Question 9.

Conditions to be imposed on subscriber's sets arranged for international communications and including either loudspeaking receivers or radio-diffusion microphones associated with amplifiers.

Question 10.

(*a*) What are the essential electrical characteristics for apparatus used to measure room noise ?
What zero reference is it advisable to specify for this measurement ?
How should this apparatus be used to measure room noises of a rapidly varying intensity ?

(*b*) What is the quantitative effect of a certain room noise on telephone transmission ?

Note.—See Appendix VII, " Study of Room Noises in Telephone Locations " by Messrs. Williams and MacCurdy, and Appendix VIII, " Noise " by Dr. K. W. Wagner.

Question 11.

Specification of a " reference system for effective transmission " which can be universally adopted and the choice of methods for measuring the effective transmission of commercial systems as a function of this " reference system for effective transmission."

Note.—The " SFERT " has been actually set up to make telephonometric comparisons between telephone circuits, that is to say comparisons of volume only. It is necessary to have " an international reference system for effective transmission " in order to compare different circuits from the point of view of effective transmission. This could be obtained by suitably modifying the actual fundamental reference system, and this will perhaps be the best method.

At the moment in U.S.A. where practical statistics of transmission used for setting up line and installation projects are already expressed as a function of the effective transmission a working standard is provisionally employed representing average line and commercial apparatus used in America. Such a working standard can be compared directly under conditions with commercial circuits of different types, and such a comparison is, for the moment, the only method of determining the values of effective transmission relative to different circuits. It seems that each country desiring to gather numerical statistics of effective transmission should set up such a working standard representing, perhaps, a typical circuit of its telephone network.

However, in order to be able to compare the results of measurements made in different countries with such working standards and to have a fixed basis of reference, which can be reproduced at will, it is necessary to specify a fundamental reference system for effective transmission and to find a method of measuring " equivalents of effective transmission " by comparison between this fundamental system and a working standard or any commercial circuit.

Questions 1, 2, 3, 7, 8, 9, 10 and 11 above belong to Class A (questions for which it is important to have an international agreement and to provide a standard method of application either universally or for the European network).

Questions 4, 5 and 6 above belong to Class B (questions of an informative nature and for which an international agreement is not important).

Members of the Fourth Commission.

The following countries to appoint Rapporteurs :—

GREAT BRITAIN : Mr. Cohen (*Chief Rapporteur*).

GERMANY : Dr. Breisig.

CHILI : Mr. R. A. Mack.

U.S.A. : Mr. W. H. Martin.

FRANCE : Mr. Chavasse.

MEXICO Mr. F. Markman.

FIFTH COMMISSION OF RAPPORTEURS.

Questions concerning co-ordination of telephone and radio-telephony.

I.—*Question to be studied by the 5th C.R.*

What conditions are to be fulfilled by a device for automatically regulating the voice volume which is introduced at the junction of a radio link and the public telephone network ?

Note.—This question belongs to Class A (questions for which it is important to have an international agreement and to provide a standard method of application, either universally or for the European network).

II.—*Questions submitted for study by the C.C.I.R., Copenhagen, 1931.*

The two following questions submitted for study by the C.C.I.R. are included here mainly for reference, since the documents collected by the C.C.I.R. on these subjects may be of interest to the members of the 5th C.R.

(*a*) *Question concerning radio-telephone service between small ships and the shore (Question No. 13 of the C.C.I.R.).*

What are the suitable means, from the technical point of view and in accordance with the Regulations, to provide a satisfactory and economical radio-telephone service between small ships—particularly those which do not come in the category prescribed by the Convention for the safeguard of human life at sea —and land stations and where necessary public telephone networks ?

What procedure should be adopted so that these ships may take advantage in case of distress of the telegraph installations on steamers equipped with wireless stations in accordance with the above mentioned Convention ?

In the case where frequencies between 1500 and 2000 kilocycles (200—150 m) will be used for this service, will it be necessary to provide a general call signal, for example 1667 kilocycles (180 m)?

Note 1.—It is desirable that these means be also suitable to provide radio telephone service between steamers near the coast and the shore telephone network.

Note 2.—This question (No. 13) has been submitted for study by the C.C.I.R. at its meeting in Copenhagen, 1931 (Presiding Administration : Germany, assisted by Belgium, Denmark, Spain, U.S.A., France, Great Britain, Dutch East Indies, Japan, Norway, Holland, Portugal).

(*b*) *Question concerning radio-telephony with moving trains* (*Question No.* 14 *of the C.C.I.R.*).

The C.C.I.R. at its meeting in Copenhagen, 1931, recommended the following :—

The C.C.I.R. considering :—

1. That the system of radio-telephony with moving trains produces currents of a radio-electric frequency, but that the radiation of Hertzian waves does not interfere with the useful transmission because the distance between the sending and receiving system is very short.

2. That the technique employed is generally similar to radio-electric technique.

3. That the propagation in space of waves transmitted by this system can only be produced at a relatively short distance compared with the range of radio-electric communications.

4. That the experience with these communications is still insufficient to allow of a definite recommendation being given.

Advise :—

That this question be studied by the different Administrations with a view to a further examination.

Accordingly the C.C.I.R. has included this question in its programme (No. 14). (Presiding Administration : Germany, assisted by U.S.A., France and Italy. Also the German Administration will ask the Canadian Administration to collaborate with them on this question.)

Members of the Fifth Commission.

The following countries to appoint Rapporteurs :—

FRANCE : Mr. L. Corbeiller (*Chief Rapporteur*).
GERMANY : Mr. Winzheimer.
ARGENTINE (Republic) : Mr. E. M. Deloraine.
DENMARK : Mr. Kay Christiansen.
SPAIN : Mr. J. M. Clara.
U.S.A. : Mr. H. E. Shreeve.
GREAT BRITAIN : Mr. A. J. Gill.
CZECHOSLOVAKIA : Messrs. Alois Singer and J. Michálek.

SIXTH AND SEVENTH COMMISSIONS OF RAPPORTEURS.

Questions of Traffic, Exploitation and Tariffs.

I.—*Questions of traffic and exploitation which have been submitted for study to the* 6*th C.R.*

Question 1.

In all international telephone conversations with Switzerland (the League of Nations) is it necessary—

1. To admit, *during the whole year*, the right to pass State calls : (*a*) to the Secretary of the League of Nations and (*b*) to the International Labour Bureau ?

2. To admit, during all the deliberations of the League of Nations, the right to pass State calls: (*a*) to members of the Council of the League of Nations, (*b*) to delegates at the League of Nations, (*c*) to delegates of the various nations asked to take part in the meetings of Commissions, Conferences, etc.?

3. To admit, without increase of tax, urgent Press calls, demanded by journalists at Geneva on the occasion of the meetings of the League of Nations, to have a priority over urgent private calls — and ordinary Press calls, demanded by these journalists, to have priority over ordinary private calls?

Question 2.

Is it not necessary to cancel Recommendation No. 32 of the C.C.I. entitled "Methods of reducing lost time on international telephone connections, due to the delay by the subscriber in answering the call of the Toll Exchange," which specifies certain operating instructions as tests?

Question 3.

In order to standardise terminology for users of the international telephone service, and at the same time to increase the interest and usefulness of the publicity created among them by Administrations and Operating Companies, is it advisable, in accordance with the wish expressed by the Telephone Committee of the International Chamber of Commerce, to edit a standard preamble (to be included in all pamphlets issued to telephone users indicating the international connections opened to service, the facilities allowed and the corresponding charges), the preamble containing (*a*) concise, though very clear information describing a conversation with préavis, and avis d'appel, a subscription call, an occasional fixed time call, etc., (*b*) advice on the manner of proceeding in these various cases, so as to co-ordinate the efforts of the users (particularly private operators on P.B.X's.) and the official operators who follow the C.C.I. instructions for international service using the agreed phrases?

Question 4.

Is it desirable to define more precisely certain fundamental data covering the methods of measuring volume of traffic, speed of service, utilisation of circuits and the general results of operation, including information on the quality of service, which is distributed among the Telephone Administrations?

Note.—In several cases, before making a comparison between the results obtained with different types of material or different kinds of service, Telephone Administrations should agree on the terms and methods of measurement used in expressing these results. This question, therefore, is associated directly with the practical realisation of improvements in service.

Some of the terms that should be studied are indicated below, and for each of them the definition adopted by the Bell System of America is given.

Calls (Demandes des Communications).

A call (demande de communication) is defined as a subscriber's original request for a connection. A request for a report or for another trial of the call is not considered as a "call" (Demande de communication).

Messages (Conversations).

A message is a call which has been completed.

Per cent. Completion (Pourcentage des demandes satisfaites).

This is the percentage of total "messages" to total "calls."

Average business day (Jour ouvrable moyen).

An average business day is any day with the exception of a Sunday, holiday or half holiday. Days of abnormal traffic; for example, those immediately preceding or following holidays or days when some public event or disaster occurs are also excluded.

Office busy hour (Heure chargée pour un bureau téléphonique).

The office busy hour is the hour during which the greatest number of outgoing calls of all categories is filed at a given office.

Circuit Group busy hour (Heure chargée pour un groupe des circuits téléphoniques).

The circuit group busy hour is the hour during which the greatest number of calls in both directions is handled over the circuit group.

Note.—The busy hours are, in general, integral clock hours, *i.e.*, 10 a.m.—11 a.m.; however, there are cases where the busy hours occur between one half hour and another, *i.e.*, 9.30—10.30 a.m.

Toll Message Circuit (Circuit téléphonique interurbain).

A toll message circuit is a telephone communication channel (physical circuit, phantom circuit, carrier path, radio link) between two toll exchanges, used for the establishment of toll messages, including subscription calls (short period talking contract calls).

Direct circuit connection (Communication directe).

A direct circuit connection is a telephone connection using only one toll message circuit to connect the calling and called subscribers.

Built-up circuit connection (Communication de transit).

A built-up circuit connection is a telephone connection necessitating the use of more than one toll message circuit to connect the calling and called subscribers.

A built-up circuit connection affecting only one intermediate exchange (or transit exchange) is called a "one-switch connection" (communication transit par un bureau); a connection affecting two intermediate exchanges is called a "two-switch connection" (communication de transit par deux bureaux), etc.

Speed of Service (Rapidité de service).

In general, in the American Bell System, by speed of service is understood the interval of time from the moment the user has finished giving the details of his call, to the moment the conversation commences (or information is given on the possibility of obtaining the particular person required).

Circuit Usage (Utilisation de circuit).

In the Bell System the expression "circuit usage" is the total time during which, in the busiest hour, a circuit is engaged either in operating or conversation. This "circuit usage" is, in general, expressed as a percentage of the total possible occupied time of the circuit.

It will be necessary also to define:

(1) "No delay service"—or "on demand service" (Trafic sans attente, ou trafic direct—Schnellverkehr).

(2) "Average delay" (attente moyenne—Mittlere Wartezeit).

Question 5.

Is it advisable to modify Recommendation No. 60 of the C.C.I., entitled "Recommendations concerning traffic statistics," to avoid the difference between the values of the mean waiting times obtained at the extremities of the same international circuit and indicated in the statistics?

Question 6.

Is it necessary, on international transit positions, to repeat calling signals transmitted over the international circuits used for a transit connection?

Note.—If the answer is in the negative, it will be possible to simplify installations, thus obtaining in economies.

Question 7.

What form of table should be definitely recommended for collecting service observation statistics of international telephone traffic, the table attached to Recommendation No. 61 of the C.C.I. being set up provisionally?

Question 8.

(*a*) Will it be possible to complete Recommendation No. 11 of the C.C.I. by regulation to be applied, in compiling directories, to the question of the classification of subscribers of the same network?

(*b*) Will it be possible to recommend to Administrations and Operating Companies in Europe, to provide in the principal European cities, the same telephone number for "police" and the same number for "fire service" in accordance with a wish of the International Chamber of Commerce.

Note.—In order to arrive at a solution of this question Administrations and Operating Companies are asked to communicate information on the method of classifying subscribers of the same network in their directories.

II. *Questions of tariffs to be studied by the 7th C.R.*

Question 9.

In telephone connections between non-adjacent countries will it not be desirable to reduce, as much as possible, the number of tariff zones? (*See* Recommendation No. 45, paragraph 2.)

Note.—The division of territories into several zones for taxing international telephone calls can be justified when it is a case of adjacent countries or very nearby countries connected by circuits which enter at different points in their territory; but they are less advantageous in the case of connections between distant countries. On the other hand, it is to the interest of the public to make tariffs as simple as possible.

Question 10.

(*a*) Is it necessary to apply a decreasing tariff for calls requested for more than a quarter of an hour during the period of light traffic?

(*b*) If not, is it advisable to include in Recommendation No. 17 of the C.C.I. "Occasional fixed time calls" the following condition, in order that there may be a logical relation between this Recommendation No. 17 and Recommendation No. 18 "Occasional international fixed time calls of long duration completed during the period of light traffic."

"For occasional fixed time calls requested during the period of light traffic and of a duration varying between more than a quarter of an hour and one hour, a tax of one hour in accordance with Recommendation No. 18 under (2) and (3) should be charged"?

Note.—The application of Recommendation No. 17, "occasional fixed time calls," and No. 18, "occasional fixed time international calls during a period of light traffic," results in the following paradoxical situation, as a result of these two recommendations not being related by a co-ordinating clause.

The unit tax for a call from Switzerland to Berlin, is 6 gold francs; during a period of light traffic, the following charges will be made for a call of 30, 45 and 58 minutes according to Recommendation No. 17.

110 gold francs for 30 minutes.
164 ,, ,, ,, 45 ,,
210.80 ,, ,, ,, 58 ,,

whilst for calls of one hour, one and a half hours, and two hours, according to Recommendation No. 18, the charges will be:—

60 gold francs for 60 minutes.
90 ,, ,, ,, 90 ,,
120 ,, ,, ,, 120 ,,

Thus 58 minutes' conversation according to Recommendation No. 17 costs almost as much as four hours according to Recommendation No. 18. Under these circumstances it is easily seen that subscribers will ask for a call of an hour's duration when they only require to speak for 20 minutes.

This calls for a co-ordination between the two recommendations.

This should be brought about as follows:—

The price of a call calculated according to Recommendation No. 17 corresponds at a certain time to the tax of a call of one hour according to Recommendation No. 18.

If X is the duration (in 3-minute periods) for which the tax calculated according to Recommendation No. 17 is equal to the tax for one hour under Recommendation No. 18, we get the following equations:—

$$\frac{\text{Tax according to Recommendation No. 17.}}{3 \times \frac{3}{5} U \times X + \frac{1}{5} U} = \frac{\text{Tax according to Recommendation No. 18.}}{\frac{1}{2} \times U \times 20}$$

where U is the unit day rate tax ($\frac{1}{5} U$ is tax during night).

From this: X periods of 3 minutes $= \left(\frac{145}{27}\right)$. The maximum duration in minutes is therefore $\frac{145 \times 3}{27} = 16\frac{1}{9}$ minutes.

If Recommendation No. 17 includes the condition proposed in the above question, there will be a logical relation between the two recommendations.

Turning to the example above, in connection with the connection Switzerland—Berlin, where the unit charge is 6 gold francs, the table below shows the logical progression of charges according to the proposed regulation:—

During period of light traffic.

5 minutes—according to Recommendation No. 17 $(3 \times \frac{3}{5} U + \frac{1}{5} U) = 20$ frs.
10 ,, ,, ,, ,, ,, = 38 ,,
15 ,, ,, ,, ,, ,, = 56 ,,
20, 30, 40, 50, 60 minutes according to Recommendation No. 18 ($\frac{1}{2} U$) = 60 ,,
70 ,, ,, ,, ,, ,, = 70 ,,
80 ,, ,, ,, ,, ,, = 80 ,,
120 ,, ,, ,, ,, ,, = 120 ,,

Question 11.

What should be the basis for calculating the charge for circuits specially set up for the transmission of music (see Recommendation No. 51 of the C.C.I., entitled "Charge for using circuits specially established for the transmission of music")?

Note.—To facilitate the study of this question the Chief Rapporteur of the 6th and 7th C.Rs. will prepare a questionnaire concerning the cost of circuits specially established for the transmission of music.

This questionnaire will be sent by the Secretary of the C.C.I. to all Administrations and Operating Companies belonging to the C.C.I. The information thus collected will be confidential, and will only be sent to members of the 6th and 7th C.Rs.

Question 12.

Is it desirable to simplify the method of division of total tax provided by Recommendation No. 9 of the C.C.I. when using emergency routes, still respecting the principle that the amount of tax charged to the users remains the same whether the normal or auxiliary route, or the emergency route is used?

Note.—One of the following solutions may be considered :—

(*a*) Corresponding to a particular transit country a certain number called " mean uniform tax " is set up which is valid for all emergency routes crossing this country. Instead of considering hypothetical transit taxes for different countries traversed by the emergency route in calculating the amounts to be paid to these countries, these " mean uniform taxes " only should be considered and to these should be applied the method of calculation given in Recommendation No. 9 of the C.C.I.

(*b*) The normal transit charge should be assigned to each transit country, the terminal countries bearing the difference between the actual charge made and the sum of the terminal and transit charges.

(*c*) A discount should only be made if the number of taxable minutes of conversation exceeds a certain minimum to be fixed.

Question 13.

Is it necessary to modify the second part of division (d), paragraph 6 of Section N-11, concerning conversations with préavis (Recommendation 25) as follows :—

If the terminal exchange is informed that the called person or his substitute can be found at a certain station of another network in the same country, the caller is advised.

If the caller wishes to accept the call with the original station, in spite of the absence of the called party, the call is completed. If the caller wishes to talk with the called person in the other network indicated, the original demand is valid but modified accordingly.

Note.—The modification covered by this question will avoid the necessity of telephone users, under these circumstances, having to make a new demand for a communication to the other network; but it can involve Administrations and Operating Companies in an extra communication equivalent to a new préavis. This question is included to see if it is necessary, in this case, to charge twice the tax for a préavis.

The Plenary Meeting will consider later the new text proposed for the List of Phrases most frequently used in International Telephone Service, revised by the 6th C.R. at their meeting in London, April, 1931, and submitted for the approval of the Plenary Meeting at Paris, September, 1931.

Question 14.

Questions 1, 2, 4, 6, 8, 10, 11, 12, 13 and 14 above belong to Class A (questions for which it is important to have an international agreement and to provide a standard method of application either universally or for the European network).

Questions 3, 5, 7 and 9 above belong to Class B (questions of an informative nature, and for which an international agreement is not important).

In the case of helping out circuits provisionally set up by a route other than the normal route which is overloaded, when circuits are available over another path ("temporary route") is it desirable to divide the normal tax between the countries concerned in such a temporary route in accordance with Recommendation 9 of the C.C.I., entitled " Emergency Routes "?

Members of the Sixth Commission.

The following countries to appoint Rapporteurs :—

BELGIUM : Mr. Fossion (*Chief Rapporteur*).
GERMANY : Mr. Höpfner.
DENMARK : Mr. Gredsted.
SPAIN : Mr. J. M. Clara.
U.S.A. : Mr. J. F. Bratney.
FRANCE : Mr. Debry.
GREAT BRITAIN : Mr. Trayfoot.
ITALY :
NORWAY : Mr. M. Wahl.
HOLLAND : Mr. H. J. Claasen.
ROUMANIA : Mr. J. Parsons.
SWEDEN : Mr. A. Lignell.
SWITZERLAND : Mr. Moeckli.
U.S.S.R. : Mr. Winetski.

Members of the Seventh Commission.

The following countries to appoint Rapporteurs :—

BELGIUM : Mr. Fossion (*Chief Rapporteur*).
GERMANY : Mr. Höpfner.
DENMARK : Mr. Gredsted.
SPAIN : Mr. J. M. Clara.
U.S.A. : Mr. J. F. Bratney.
FRANCE : Mr. Debry.
GREAT BRITAIN : Mr. B. L. BARNETT.
ITALY :
HOLLAND : Mr. H. J. Claasen.
ROUMANIA : Mr. J. Parsons.
SWEDEN : Mr. A. Lignell.
SWITZERLAND : Mr. Moeckli.
CZECHOSLOVAKIA : Mr. V. Kucera.
U.S.S.R. : Mme. Dobrouskina.

Mr. Lange : The Meeting must now appoint the Chief Rapporteurs for the Seven Commissions. I think the mandate of the actual Chief Rapporteurs will be confirmed as follows :—

For the 1st C.R.	Dr. Jäger.
For the 2nd C.R....	Dr. Breisig.
For the 3rd C.R.	Mr. Höpfner.
For the 4th C.R.	Mr. Cohen.
For the 5th C.R.	Mr. Le Corbeiller,
For the 6th and 7th C.R.s	Mr. Fossion.

Madame, Messieurs, the work of the 8th Meeting is finished. If we look back, we can say, with satisfaction, that we have accomplished good work, aiming at the solution of problems, often important and difficult, which the technical and operating developments of telephony have brought to light. But we have also prepared for future work by providing for the continuation of studies at present under consideration and the solution of new questions. And so the cycle goes on. Each year brings its harvest, and the results acquired do not leave any doubt as to the fruitfulness of our efforts.

It only remains for me, now, to thank the Vice-Presidents, Colonel Sir Thomas Purves, Dr. Breisig and Mr. Muri, for having so competently brought our labours to a satisfactory ending.

I also offer my thanks to the Members of the Commissions of Rapporteurs, and particularly to the Chief Rapporteurs, Dr. Jäger, Dr. Breisig, Mr. Höpfner, Mr. Cohen, Mr. Le Corbeiller and Mr. Fossion, who have so well prepared our task. In the main, each of us has put his shoulder to the wheel, and I say this with general and mutual gratitude.

Finally, I thank the Bureau, not forgetting our devoted Secretary, who has had to face this week, and more so during the last two days, such a formidable task.

Madame, Messieurs, I hope that you have enjoyed your stay in Paris. I wish you *bon voyage* on your return to your respective countries, and the best of health.

Mr. Hernandez Barroso : Madame, Messieurs, I have pleasure in expressing, in the name of the Spanish Delegation, our feelings of gratitude and cordiality towards the French Administration, and in particular to the Reception Committee, for all the care they have taken in making our stay in Paris so enjoyable. I believe I am also speaking for all the Delegations in expressing my thanks.

May I also express a sentiment of the Spanish Republic: we represent long-distance telephone communication; the telephone network (one with the telegraph network) is the nerve system of the world which permits people to come into direct contact with one another and to better understand one another; in this way sentiments of universal peace can be fostered, a peace which we hope will be definitely accomplished as soon as possible.

As representatives of world telephone communication, we can, in our respective countries, be amongst the greatest workers for universal peace, and it is this feeling we wish to take back to our country. (Applause.)

Colonel Sir Thomas Purves: Madame, Messieurs, we cannot close this meeting without expressing our thanks to Mr. Lange, who has presided over this Assembly with such courtesy and ability. (Applause.)

Mr. Lange: Madame, Messieurs, I have merely followed, very modestly, the example of my predecessors, and in particular the example of Sir Thomas Purves himself.

Mr. Valensi: Madame, Messieurs, allow me, before this meeting closes, to say how deeply touched I was at the words of praise that have been addressed to me. I feel it my duty to pass them on to my colleagues, the Secretaries, Messrs. Bigorgne, Ollier, Labrousse and Legros. Nor do I wish to forget the personnel of the Secretariat, who, under Mr. Lavoignat, have done such important stenographic and copying work. For myself, I am very happy to be associated with such work.

The Meeting adjourned at 12 o'clock.

APPENDIX I.

CONCERNING THE NEW QUESTION NO. 1 OF THE THIRD COMMISSION OF ASSESSORS.

Note on the use of Automatic Level Recorders.

By applying measuring methods with automatic recorders on international telephone circuits, it is possible considerably to reduce the time the circuits are occupied by measurements. For this reason it is advisable to use these methods. In particular, level diagrams can well be made automatically, and below are given the conditions which an automatic level recorder must fulfil for use in the international telephone service.

It is important that the method of level measurements prescribed for the international service should also be used in automatic recorders. Consequently, in the case of international circuits, the transmitting system must be a normal type of generator, having an effective internal resistance of 600 ohms, and transmit a power of 1 milliwatt into an external resistance of 600 ohms. (For circuits relaying broadcast programmes *see* the Appendix No. II., which follows.)

The method of level measurement can be so arranged—when it concerns the automatic recording of levels—that the frequency of the generator connected to the sending end of the line varies as a function of the time. The receiving apparatus connected at the receiving end of the line, or at an intermediate point, will register the received voltage and draw the level diagram.

It is possible to determine in several ways the transmitted frequency corresponding to any given point of the diagram. One of the possible methods is the following: A continuous and well defined series of different frequencies is transmitted, so that when a point in the scale of frequencies is identified the whole scale of frequencies in relation to the time scale is obtained without ambiguity. Another procedure consists in identifying several frequencies at intervals known one from the other (for example, with 100 p: s intervals or corresponding to an octave) so that the intermediate frequencies are interpolated. For example, for the identification of certain frequencies, the transmitted voltage can be interrupted during a short time for the frequencies under consideration. The first method is much the better one, and for that reason it is recommended for international service.

It is preferable that the series of frequencies transmitted should not be linear (that is to say, bands of frequencies of equal width are not transmitted in equal time intervals), for the diagram would become too congested, particularly in the case of circuits relaying radio-broadcast transmissions.

It is better to adopt a logarithmic series of frequencies by transmitting an octave in each definite time interval. It seems advantageous to specify the length of time for the sending of an octave, because, in the case of a later modification of the frequency band to be measured, the new sending duration can easily be determined without having to change in any way the measuring arrangements already used for measuring the previous frequency bands. A duration of 15 seconds has been acknowledged to be convenient. Its adoption in the international service is consequently proposed. If, in exceptional cases, it is required that the frequencies should be transmitted in a slower rhythm (for example, in the case of a circuit with abnormally rapid variations of the equivalent with frequency) it is advisable to recommend a duration which is a multiple of the normal deviation, preferably the multiple 4 ; that is to say, 60 seconds for an octave.

When the frequencies are distributed in a logarithmic series, it is advisable to adopt the measurement range 30-10 000 p:s. In order not to extend too much the abscissa of the level diagram, a scale different from the logarithmic scale, preferably linear, can be used below 100 p : s.

The measurements should commence with the lower frequencies and continue with the higher frequencies.

As an indication of the time, the use is recommended of a starting signal sent at a certain fixed time, before the transmission of a series of measuring frequencies is commenced. For this fixed interval of time between the commencement of the starting signal and the sending of 30 p:s on the circuit, a value of 6.5 seconds is proposed. The starting signal can be used to commence the operation of the clockwork movement of the automatic recorder. In this case, the attenuation and frequency scale can be printed in advance on the recording band.

In order that recorders of different manufacture can be used together, the conditions of the automatic sending of the starting signal must be standardised. It is proposed to use 1300 p:s, with a sending voltage into the line equal to the voltage corresponding to zero level, the starting signal having a duration at least equal to one-tenth of the duration of an octave, that is, 1.5 second.

For measurements made on international circuits, apparatus, of which the commencement of operation is not automatic, can be also used. In this case, the starting signal must be considered as the guiding point of the graduation of the frequency scale.

It does not seem necessary for the moment to propose limits concerning the recommended values, since the tolerances, which can be admitted from an economical standpoint, are not known.

Below will be found (in order of importance) the questions which must form the object of international regulations.

(*a*) Bands of frequencies utilised for the measurements.

(*b*) Law of succession of frequencies used for the measurements (logarithmic or linear scale ; frequencies ascending or descending).

(*c*) Duration of the sending of an octave.

(*d*) Method of identification of the frequencies and characteristics of starting signal ; what should be the interval between the starting signal and the commencement of sending the measuring frequencies ? Frequency of the current used for the starting signal ? Duration of the starting signal ?

Note.—In the Recommendations issued by the Plenary Assembly of the C.C.I. under the title " Electrical conditions to be considered as a criterion of the good condition of the lines for relaying radio broadcast transmissions " (*see* p. 84) as well as in Appendix B.c.4, No. 8, entitled " Instructions for the setting up of specifications of Repeater Stations with respect to testing and measuring apparatus," (*see* p. 152), provisional values have been recommended for the characteristics of automatic level recorders.

APPENDIX II.

CONCERNING THE NEW QUESTION NO. 1 OF THE THIRD COMMISSION OF ASSESSORS.

Information relating to the use of automatic level recorders for measurements made on circuits relaying radio-broadcast transmissions.

For measuring the level on circuits relaying radio-broadcast transmissions, a method is used which is slightly different from that used on ordinary telephone circuits. In the place of a normal generator having an internal resistance of 600 ohms, and an open circuit voltage of 1.55 volts, a generator of lower resistance is used so that the voltage at the input of the line is constant (whatever its impedance) and equal to the open circuit voltage of the generator (0.775 volt) which corresponds to the absolute zero level (voltage). This procedure of defining the voltage level is advantageous in that the ordinary measuring apparatus can serve to measure the voltage whatever is the line impedance.

In order that an automatic recorder should be used for such a measurement, the normal generator (internal resistance 600 ohms) must be replaced by a generator of lower internal resistance, and having an open circuit voltage of 0.775 volt.

The other questions in the preceding Appendix No. I. can be solved, in the case of circuits relaying radio-broadcast transmission, in the same manner as for the automatic level recorders for ordinary telephone circuits. It is desirable to arrive at an agreement on this subject, so that the same automatic recorder can be used for both cases by simply changing the generator.

APPENDIX III.

CONCERNING THE NEW QUESTION NO. 15 OF THE THIRD COMMISSION OF ASSESSORS.

FIRST PART.—Method of test proposed for the study of the effect of the time of propagation on the quality of the telephone transmission.

1. General Conditions.

In addition to its effects upon echoes, the propagation time produces two other effects :—

(*a*) Speech is transmitted with less rapidity owing to the time necessary for the transmission in either direction of the circuit; in consequence the impression is produced that the person at the other end of the line is too slow in replying, and this can produce a certain embarrassment in the carrying out of conversation.

(*b*) When the time of transmission becomes appreciable, it is necessary to employ voice operated arrangements, which introduces an additional delay to the transmission. In certain cases it may be difficult for one of the subscribers to interrupt the other, and in other cases parts of the conversation may be cut off.

When the circuits contain voice operated devices, several conditions can be obtained. Among them are the following :—

(*a*) Circuits having a single echo suppressor situated, for example, at the centre of the circuit.

(*b*) Circuits having two echo suppressors.

In the case of a single echo suppressor, it is necessary that, once it is operated, it should remain in that position until the echoes have disappeared. This blocking will prevent the listening subscriber from interrupting the talker until the latter pauses for a duration equal to the blocking time.

The case of two echo suppressors of the normal reversible operation type, being connected on a circuit, is the more important.

In such a case, if the two subscribers commence to talk at about the same instant, neither of the two will succeed in transmitting, as each one will operate the echo suppressor nearest to him which will prevent the speech from the other subscriber from passing. Consequently portions of the conversations will be cut out. If the time of transmission between two echo suppressors is increased, this will also increase the probability of conversation difficulties between the two subscribers, as the interval of time during which the two subscribers can commence to speak simultaneously and in consequence block each other, will also increase.

The same happens when there are more than two echo suppressors on the circuit, provided that the suppressors situated between the two suppressors which are nearest to the subscribers, do not themselves add to the effect of the cut out periods.

If, instead of reversible echo suppressors, reaction suppressors are used the same effects are, in general, obtained. In addition, as it is necessary to give to the reaction suppressors a greater sensitivity than that of the echo suppressors with regard to the speech current they are also more susceptible to be operated by induced noise.

Proposed Methods of Testing.

Since the effect of transmission time on the quality of the transmission is greater when the circuit contains voice operated devices (*e.g.* echo suppressors) and since it is necessary to use such devices when the transmission time is considerable, it is recommended that tests (to determine the effect of transmission time on the transmission quality) should be made, principally on circuits containing voice operated devices, and in particular, on those which contain two of these devices situated at a considerable distance from each other.

It is useful in these tests to vary the transmission time on the complete circuit between 0.1 and 0.5 second, and the time of propagation between the distant voice-operated devices between 50 and 100 per cent. of these values.

To obtain these different transmission times without changing the other characteristics of the circuit, several means can be employed, among which are:—

(*a*) **Phonographic Records.**—The talker's voice waves are recorded on a phonograph, and the impressions are picked up by a reproducing system at a certain interval. The relative displacement of the two systems, recording and reproducing, are regulated so as to obtain the desired transmission time. (*See* later in the second part of the present Appendix the means of making such tests which have been used in Germany.)

(*b*) Insertion of acoustic tubes of different lengths between the receiver (situated at the receiving end of the first telephone system) and the transmitter (situated at the sending end of a second telephone system) an operator speaking into the microphone situated at the sending end of the first telephone system, whilst another operator listens at the receiving end of the second telephone system.

The American Telephone and Telegraph Company has applied this method of test. To obtain a desired value of transmission time an acoustic tube was used the length of which was determined in accordance with the speed of sound in the air, which is of the order of 300 to 400 metres per second.

Whatever experimental means are used, the test circuit must have characteristics which are comparable with a commercial telephone circuit from the point of speech volume, distortion, noise and other electrical characteristics.

It is also possible to make such tests by adding sufficient length of loaded cable to the circuit until the desired time of transmission is obtained. In this case the effect obtained will be the result of the combination of the effect of increase in the transmission time, and the other effect produced by variation of the electrical characteristics due to the insertion of the additional cable. Consequently it would, in general, be difficult to appreciate the influence of the transmission time by itself.

Operating Method.

(a) **Monitoring Tests.** A good operative method consists in introducing a certain transmission time in a commercial circuit (preferably without the knowledge of the subscribers) and to supervise the conversation with care in noting the effect of the introduction of the transmission time.

Since such tests will impair the quality of the service and since the conversations will be listened to systematically, the tests should be made on circuits reserved exclusively for the personnel of the Telephone Administration.

The object of monitoring the conversations can be to determine the following factors:—

(*a*) Complaints or comments of the subscribers.
(*b*) Number of repetitions per 100 seconds of conversation.
(*c*) Number and length of interruptions ("holes") in the conversation.
(*d*) Percentage of time lost.
(*e*) Number of words effectively transmitted on the circuit per minute (excluding repetitions).

The lost time mentioned above should include :—

1. The time lost due to the time of transmission itself, *e.g.*, the product of the transmission time and the number of times that each subscriber must wait for the speech to reach him.
2. The time during which the circuit is not used due to "holes" in the conversation.
3. The time lost by repetitions due to the effect of the transmission time. (This is determined by comparison with the case where the transmission time is negligible, all the other conditions remaining the same.)
4. The time lost by complaints or unfavourable comments.

In these kinds of observations experienced engineers (appreciating clearly the object of the tests and capable of establishing in detail the instructions to follow during the supervision in order to obtain results which are comparable for different conditions of tests) must, at least at the commencement, take part themselves in observing the conversations.

(b) **Appreciation Tests.** Another operating method, which is however less quantitative, consists of several observers speaking over a circuit of which the time of transmission is varied, and noting the appreciations expressed by these observers as to the facility of the conversation. For such tests a two-way circuit must be used which produces the conditions of a commercial conversation. Experience has shown, however, that with such tests large differences between individual appreciations are usually obtained.

Interpretation of Results.

At present the interpretation of results of tests made to determine the effect of transmission times on the quality of telephone transmission is largely a question of judgment. It is to be hoped that as more experimental results are received, not only will the methods indicated above be found to be increasingly useful, but new and more useful methods will be instigated and that precise interpretation of the results will be obtained.

SECOND PART.—Report on experiments made in Germany to determine the maximum permissible transmission time on long international telephone circuits, by Mr. Hans Decker. (Communicated by the German Telephone Administration.)

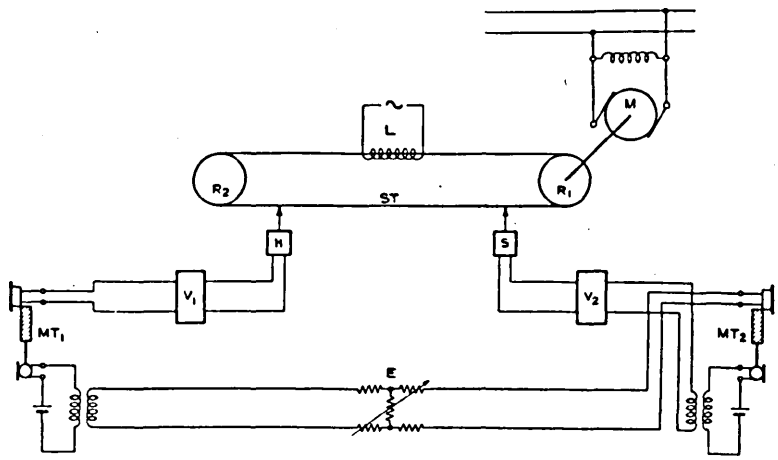
In order to be able to reply to the question concerning the maximum permissible value for the transmission time on long international circuits, it is necessary to have a transmission system of which the transmission time can be varied at will, whilst the equivalent, attenuation distortion, non-linear distortion, phase distortion, echo effects and noise do not (when the transmission time is varied) exceed those values recommended by the C.C.I. for long international telephone circuits. On the other hand, it is necessary that in this transmission system having a variable transmission time, the equivalent, the distortions and the disturbances do not change (when the transmission time is varied) in order that the transmission time shall be the only variable among all the factors influencing the transmission quality. Lastly, it is necessary that a large number of observers of different temperament exchange conversations on the system, since the appreciation of the different observers concerning the transmission time which they consider as not affecting the exchange of conversations, will differ considerably according to their temperaments. During the test described below, it was found that in addition to the temperaments of the observers, other psychological factors influence the appreciation of the transmission time considered as not troubling telephone conversation. Among these are, notably, the difference in administrative or social positions of the two persons conversing on a circuit with variable transmission time. For example, when a high official speaks to a subordinate; that is to say, when one only speaks when the other asks a question, then even in the case of a quick temperament, a considerably greater transmission time can be permitted than when the two subscribers have the same position from the economical, administrative or social standpoint. In the latter case it was possible, during the tests relating to the transmission time, to make psychological observations which were as follows:—

The transmission times of long duration are particularly annoying for very polite subscribers who do not like to break in upon the speech of the other subscriber. The subscriber X, for example, stops speaking for a very short interval of time; the subscriber Y has then the impression that X has finished speaking and he commences to speak in his turn, but before the first syllable uttered by Y arrives at the ear of X, the latter continues to speak. Such an obstacle to the listening of the conversation is not annoying if one of the subscribers continues to speak after both have found they have cut off each other's speech. But if each of them tries not to interrupt the other, X and Y will both cease to speak in the middle of a commenced phrase, and in this case a total stoppage of the conversation will result. This stoppage will end at the latest when, after having spoken some syllables, X as well as Y, will remark to each other that they have stopped each other from speaking. Accordingly continued stopping and restarting of the conversation may take place, and for such a case a transmission time, which for other subscribers is quite permissible, will not be satisfactory.

Fig. 1 shows the arrangement used by the Research Department of the German Telephone Administration (Reichspostzentralamt) for determining the permissible transmission time. The arrangement fulfils the necessary technical conditions, and is so easy to operate that it was possible to utilise a large number of observers for the tests.

Two microtelephone sets, MT_1 and MT_2 are connected together in such a manner that an echo can only be produced by acoustic coupling of the receiver and transmitter of each set. This echo is sufficiently weak to pass unperceived if particular attention is not paid to it. The voice currents produced by the transmitter of the subscriber's set MT_2, arrive at amplifier V_2 and after amplification pass through the inductance coil S which produces an alternating magnetic field applied to a steel ribbon ST. The steel ribbon has a width of 3 mm, a thickness of 0.05 mm, and a length of about 9 metres. Its two ends are soldered together and it passes over the pulleys R_1 and R_2. R_2 turns freely about its axis and R_1 is controlled by a motor in such a manner that the steel ribbon moves at the rate of about 3 metres per

second, and it carries at this same speed, in the form of remanent magnetism, the magnetic inscription recorded when passing in the inductance coil S. Under the effect of this remanent magnetism, alternating voltages are produced in the reproducing coil H, and after amplification in V_1, pass through the receiver of the subscriber's set MT_1. In consequence the telephone currents carried by the steel ribbon in the form of magnetic recording, are delayed by a/v seconds in their passage from the transmitter of MT_2 and the receiver of MT_1, where a is the distance in centimetres between S and H, and v the speed of the steel ribbon in cm per second.



E - STANDARD ARTIFICIAL LINE.
H - REPRODUCING COIL.
L - DEMAGNETISING COIL.
M - MOTOR.
MT1 & MT2 - HAND SETS.
R1 & R2 - PULLEYS.
S - RECORDING COIL (MAGNETIC RECORDING OF THE SOUNDS ON A STEEL TAPE).
ST - STEEL TAPE.
V1 & V2 - AMPLIFIERS.

FIG. 1.

In order that the steel ribbon is not magnetised when it returns to S, the ribbon passes through a demagnetising coil when it returns from H towards S. This demagnetising coil is fed by an alternating current source the frequency of which is sufficiently high to avoid disturbing noise, and so that it is not noticed in the telephone receiver. In Figure 1, L represents the alternating current source and demagnetising coil.

To study the effect of a large transmission time on the carrying out of conversations, it is sufficient if one direction of the transmission system has a variable transmission time, and it is for this reason that in the arrangement shown schematically in Fig. 1, the delay arrangement is only in one direction of transmission while the direction between the transmitter of MT_1 and the receiver of MT_2 consists of an artificial line E, the attenuation of which is 2.0 népers. The equivalent of the path between the transmitter of MT_2 and the receiver of MT_1 (passing by V_2—S—S_1—H and V_1) is also 2.0 nepers. If $\frac{a}{v} = 2t$, then from the point of view of transmission time the arrangement represented by Fig. 1 is equivalent to a telephone circuit having a transmission time $t \ \frac{a}{2v} =$ in each direction of transmission.

The measuring arrangement described above, and of which the equivalent in the two directions of transmission is 2 népers, was used by 22 pairs of different observers, with a delay of $\frac{a}{v} = 2t = 2.74$ seconds, corresponding to a transmission time of 1.37 seconds in each direction of a 4-wire circuit. The observers commence conversation, and when this becomes difficult, due to the delay in receiving the replies, the observers ask that the delay should be reduced until no further difficulties are caused to the conversation. In Fig. 2 is shown, in order of increasing values, the transmission time that the 22 pairs

of observers considered as not hindering the conversation. The abscissa indicates the value of the transmission time for an equivalent 4-wire circuit, that is to say the transmission time $t = \frac{a}{2v}$ where a represents the distance between S and H (Fig. 1), expressed in centimetres and v the speed of the steel ribbon ST expressed in centimetres per second. From Fig. 2 it will be seen that 2 pairs of observers considered that a transmission time of 1.37 second is not disturbing ; 11 pairs (half of the total) experienced no difficulty when the transmission time was equal to or less than 0.4 second ; 2 pairs only considered that the transmission time should be equal to or less than 0.3 second.

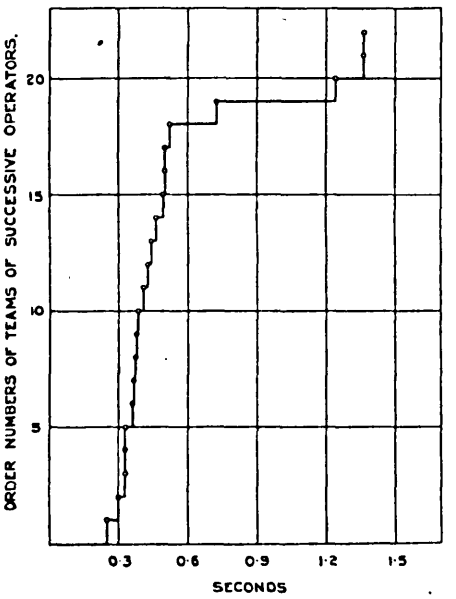


FIG. 2.

It is possible that investigators in other countries, when using a transmission system corresponding to Fig. 1, to measure the maximum permissible value of the transmission time, will arrive at conclusions differing from those of the German observers, and that according to their temperaments will consider permissible greater or larger transmission times. It is, therefore, desirable that the tests in question be undertaken by other Administrations belonging to the C.C.I. and that they communicate their results to the C.C.I. It is to facilitate the making of such investigations that a description of the method used by the German Administration has been given; a method which has been found to be very practical.

APPENDIX IV.

Concerning Question No. 1 of the Fourth Commission of Rapporteurs. Speech Power and Its Measurement.*

By L. J. SIVIAN.

(*Article published in the "Bell System Technical Journal," No. 4, October, 1929, pp. 646-661.*)†

The paper is chiefly concerned with the important speech power quantities—frequency spectra, distributions of instantaneous, average, syllabic and peak amplitudes, etc.—as they obtain in actual speech for a large range of voices, talking levels, and subject matters. The analysis is not nearly so complete nor so fine-grained as that which, in principle, can be derived from oscillographic records of individual speech sounds. Its advantage is in the speed with which data can be secured, under widely varying conditions and on a scale which warrants statistical conclusions. Some of the methods in use for measurements of this type are described. A "level analyser" has been developed, primarily for the measurement of average and peak pressure amplitudes in speech and music, both as to magnitude and as to position in the frequency spectrum. Illustrative results are given for examples of speech, music and noise.

Speech sounds are so variable from one to another, from one individual to another, from one conversation to another, as to make it necessary to deal with speech power in a statistical manner. This

* Presented before Acoustical Society of America, 11th May, 1929.
† *See* pp. 317-223 for the Figs. referred to in this article.

is particularly true of engineering applications, as distinguished from studies in phonetics and voice dynamics. It is largely from the viewpoint of the former that the subject is here treated.

Speech power occurs in several states, *e.g.* acoustic, electric, magnetic, mechanical, optical, thermal, etc., but its measurement largely refers to speech in the acoustic or in the electric form. Acoustically, the simplest quantity to define is the instantaneous power transmitted through unit area tangent to the wave front. That power is $L = P \cdot U$, where P is the pressure and U the air particle velocity. With P expressed in bars (dynes per cm^2), and U in cm/sec., L is given in ergs/cm^2 $\times$ sec. We do not directly measure the product $P \cdot U$. No suitable means for doing that has been developed. In a progressive plane wave, or with good approximation in any progressive wave at sufficient distance from the source, P and U are in phase, and the expression for L simplifies down to $L = P^2/\rho c$, where ρc is a constant equal to 41.5 mechanical ohms—the sound radiation resistance of air. Hence for the type of waves mentioned the wattmeter type of measurement (pressure $\times$ velocity, corresponding to voltage $\times$ current in the electrical case) may be replaced with the simpler measurement of pressure (voltage) or velocity (current) alone.

What are the acoustic voltmeters and ammeters that are capable of measuring the instantaneous pressures and velocities respectively? First, as to acoustic ammeters: perhaps the two best known forms are the Rayleigh disc and the hot-wire microphone. The disc gives absolute values of U but its response is so slow that it can be used only to measure the effective values in comparatively sustained sound waves lasting, say, one second or longer, or for the ballistic integration of shorter pulses. Hence it does not give a measure of the instantaneous velocities for even the slowest audio-frequency vibration. Furthermore, its use when exposed to the speaker in an open room, is rendered difficult by its susceptibility to spurious air currents. The only application of the disc to vocal power measurements which has come to my notice, is one by Prof. Zernov,* published in 1908. For sustained loud singing and shouting he found energy densities ranging from 0.3 to 2.0 $\times$ 10^{-4} ergs/cm^3, at 2 metres distance from the singer. Assuming uniform distribution over a hemisphere of 2 m radius, this gives a total power output of the voice of the order of 50 000 microwatts. At 2 m. distance reflections from the walls of the room materially raise the energy density as compared with that in a progressive wave.

Another acoustic ammeter is the hot-wire microphone. The resistance variations of the wire tend to follow the instantaneous values of the air particle velocity in the sound wave, but the sensitivity is a complicated function of the frequency, rapidly decreasing as the latter increases. Hence it does not give true oscillograms of speech sounds, which in general include a frequency range of six or seven octaves.

Still another device in this general class is the glow-discharge microphone. Its response is determined largely by the amplitude of the air particle motion (E. Meyer, E.N.T., v. 6, 17-21, 1929). Hence, for constant sound intensity the response is inversely proportional to the frequency, roughly. No method for its absolute calibration has been proposed other than comparison with a microphone of known performance. The frequency response and the somewhat erratic behaviour of the device in its present status render it rather unsuitable for speech power studies.

Nearly all our information concerning speech power and the wave-form of speech sounds has been obtained with acoustic voltmeters, *i.e.*, with devices responding to pressure in the sound wave. To a first approximation, the ear belongs to this class. It includes the resonators which Helmholtz used in his vowel studies. Generally, the vital element in these devices is a diaphragm which vibrates with the alternating sound pressure, and whose motion is converted (indirectly, as a rule) into a visual record. These acoustic voltmeters have gradually evolved from Scott's phonautograph and Koenig's manometric capsules and indicating flames of some 70 years ago to the present day technique. Their extensive use accounts for the fact that sound measurements are frequently expressed in terms of pressure rather than

* *Ann. der Phys.*, 26, 94, 1908.

in terms of power. In many cases, when the relation between pressure and velocity is not known or too complex a function of frequency to be manageable, the description of the sound wave must be confined to pressure values alone.

The first requisite for absolute measurements of speech pressures is a microphone which admits of an absolute electro-acoustic calibration over the range of audio frequencies, and which has a substantially uniform sensitivity over the most important part of that range. The development of the condenser microphone and of the thermophone method for calibrating it, supplied this need. This fundamental contribution to the subject is due to E. C. Wente.* Using such a calibrated condenser microphone in conjunction with a vacuum tube amplifier and an oscillograph which were uniformly sensitive up to about 6 000 p : s, I. B. Crandall and C. F. Sacia†, and I. B. Crandall† obtained oscillograms of the fundamental speech sounds in the English language. Essentially, these oscillograms give a picture of the instantaneous pressures throughout the duration of the sound impressed on the microphone diaphragm, at 2.5 cm from the speaker's lips. A certain amount of similar work on German speech sounds has been published by Trendelenburg.‡ From the standpoint of phonetics these pressure amplitude oscillograms of individual sounds are a most comprehensive source of information. Their chief use has been in determining the frequency spectra of the fundamental speech sounds. Sacia § and Sacia and Beck ‖ have used them to compute the mean and the peak powers of those sounds.

From the standpoint of engineering applications, speech power has a twofold interest: (*a*) there is the question of designing microphones, receivers, circuits, room acoustics, of controlling noise levels, etc., (*b*) the control of apparatus (chiefly adjustment of amplification) while it is handling speech from persons who acoustically are not controllable.

In connection with (*a*) we can use data obtained under "laboratory" conditions, *i.e.* with the speakers, their voice levels, the talking speed, etc., suitably selected. Perhaps the simplest statistical characteristic of speech is the average power, *i.e.* the ratio of the total energy in a large number of speech sounds divided by the total speech time. The quantity immediately measured is the pressure on the transmitter diaphragm. The corresponding power flow through unit area is computed. In doing so it is roughly assumed that the pressure on the diaphragm is twice as great as it would be in free air, which is assuming total reflection by the transmitter. It is further assumed that the power flow is uniform over a hemisphere whose radius is the distance from the speaker's lips to the diaphragm. For this average power flow with "normally modulated" voices, Crandall and Mackenzie ¶ found the value of 12.5 microwatts. More recently Sacia § gave 7.4 microwatts, including pauses between speech sounds, which occupied about one-third of the total time. Some measurements made since then have led to substantially similar values, and so the value of 10 microwatts may be taken as fairly representative of a normal level. The corresponding average pressure on the diaphragm, at 5 cm distance from the lips, was found to be about 5 bars. The averaging, of course, is for the absolute values of the pressures. Some notion of the level involved may be gained by noting that it is decidedly fatiguing to maintain a speech level 20 db higher for more than a few seconds.

It should be noted that the distributions of the instantaneous power and instantaneous pressure values in respect to their average values are quite different for speech from what they are in a sinusoidal wave. Fig. 1 and Fig. 2 show the extent of the difference for powers and pressures respectively. Clearly, speech as a whole is decidedly more "peaked" than a sinusoidal wave. Values of peak factors for individual speech sounds, *i.e.* the ratio of peak amplitude to mean effective amplitude, are given in Sacia's paper.

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* *Phys. Rev.*, July 1917, April 1922, June 1922.
† *Bell Sys. Tech. Jour.*, April, 1924 and October, 1925, resp.
‡ *Wiss. Veroff. a. d. Siemens-Konzern*, 1924 and 1925.
§ *Bell Sys. Tech. Jour.*, October, 1925.
‖ *Bell Sys. Tech. Jour.*, July, 1926.
¶ *Phys. Rev.*, March, 1922.

A paramount characteristic of speech is the distribution of power and pressure in the frequency spectrum. That is so because in general the systems responding to or carrying speech (including the ear) have pronounced frequency characteristics. The same is true of noise sources interfering with speech. Here, as for total powers and pressures, the simplest quantity is the average spectrum for a large number of speech sounds. Crandall and Mackenzie * obtained the energy spectrum shown in Fig. 3, based on speech from six voices. They used a condenser microphone whose output was analysed by a series of resonant circuits covering the range from 75 to 5000 p:s. Fig. 4 shows a recent determination in which the average pressure is given as a function of frequency. The apparatus used to obtain the data will be described in detail elsewhere. Briefly a series of band-pass filters are used to separate the frequency components. The output of any one filter goes into a rectilinear vacuum tube rectifier, and a fluxmeter integrates the rectified current over the duration of the speech. Simultaneously with this measurement the total spectrum is also rectified and integrated. The integration periods used were 15 seconds long. The pressure in any one band is given by the product: ($10^{0.05\alpha}$ × band width in cycles × total pressure), where α is the ordinate expressed in decibels (db). In using average spectra of this sort it is well to remember that they are determined not only by the amplitudes in the individual speech sounds but equally by frequency of occurrence. Thus the fact that nearly all vowels for male voices at normal levels have a fundamental frequency between 80 and 150 p:s tends to accentuate that region, even though the fundamental amplitudes in individual speech sounds are not outstandingly large.

The data in Fig. 4 are for close talking conditions, 5 cm from the lips to the diaphragm. Fig. 5 shows the effect of distance on the spectral distribution. The two distances are 5 cm and 90 cm respectively, the transmitter in both cases being set into a large fibre-board wall. The shapes of the two spectra are almost identical, indicating that, on the average, even at 5 cm the condenser microphone does not greatly affect the voice as a sound generator. The largest difference between the two is in the lowest band, from 62 to 125 p:s perhaps owing to the relatively low radiation efficiency of the voice at those frequencies.

The ratio of the distances is 18 : 1; that of the average pressures 14 : 1. The average pressure is nearly inversely proportional to the distance, part of the difference probably being chargeable to the more nearly total reflection for the distant condition. It is implied, of course, that even for the latter condition the direct sound is large compared with that reaching the microphone by reflections.

So far the spectra discussed were those of normally modulated voices. Fig. 6 shows what happens to the average spectrum when a high, rather declamatory level is adopted. The higher level is relatively poorer in frequencies below 500 p:s, relatively richer between 500 and 4000 p:s, and above 4000 p:s its spectrum is nearly the same as for normal levels. The decrease at low frequencies is most pronounced in the band from 62 to 125 p:s, *i.e.* in the region of the voice fundamental frequency at normal levels. This leaves two possibilities. Either at the high speech level the fundamental frequency is the same as for normal, but its amplitude is relatively small: and the spacing of the overtones is the same as at normal levels. Or else—and more probably as indicated by the auditory pitch sense—passage to the high level is attended by an actual upward shifting of the fundamental frequency, and a correspondingly larger spacing of the overtones. In addition the amplitude of this new fundamental would be relatively lower than for the normal level. The average spectrum method is incapable of deciding between the two alternatives. Some oscillograms were made at normal and high speech levels, which clearly indicated that the second alternative is the correct one, or at least the prevalent one. For most vowel sounds, the fundamental frequency was found shifted from about 100 p:s at normal, to about 200 p:s at the higher level. This result has an intimate bearing on the loss of naturalness encountered when speech originally picked up at normal voice levels is subsequently reproduced at much higher levels. A corresponding

* *Phys. Rev.*, March, 1922.

change, though in the opposite direction, probably takes place in going from normal to subnormal levels. Some evidence of this will be seen in the section on peak amplitudes.

The method of average pressure-frequency spectra is equally applicable to sounds other than speech, provided they are sustained or can be repeated. Two illustrations are given. Fig. 7 is for a piano composition. Characteristic in comparison with speech is the relative smallness of high frequencies. Spectra of radically different types of compositions were found to be rather similar. The instrument, the room acoustics and the position of the microphone largely determine the picture. In this case, the microphone was about 7 ft. from the keyboard, and the reverberation time between 1.2 seconds at 100 p : s. and 1.0 second at 4000 p : s.

Fig. 8 gives the spectrum of street noise entering a laboratory window, ten floors above the street. Street traffic and an elevated railway are the chief contributors, the measurements being taken during traffic peak hours. The relative poverty in high frequencies is even more pronounced than for the piano.

We shall now consider the type of apparatus intended primarily for measurements when the speakers are not acoustically controllable. Instead of averaging over a large number of words the measurement is essentially that of mean power in syllables. Usually it covers the whole spectrum rather than a particular frequency band. It has been widely used for controlling amplification in radio broadcasting, in phonograph and film recording of speech, and for rapid measurement and electrical control of speech levels in telephone conversations. A typical device of this sort is the " volume indicator " * shown in Fig. 9, developed about ten years ago. Essentially it is a vacuum tube rectifier with a rapid action D.C. meter in the plate circuit. It is operated on a part of the characteristic such that the rectified plate current is roughly proportional to the square of the speech voltage. The rectifier is preceded by an amplifier of adjustable gain. For the speech level under measurement the gain is adjusted to such a value that the fluctuating meter deflections attain a prescribed maximum value on the average of once in about three seconds. That value of gain, expressed in decibels with respect to a certain normal value of the gain, gives the volume indicator measure of the speech level. The meter combined with the electric circuit has a dynamic characteristic as shown in the curve, which gives the maximum deflection as a function of the duration of the A.C. input. For inputs lasting more than about 0.18 second the maximum deflection remains the same. Since the average syllable duration is of the order of 0.2 second, it follows that the maximum deflection of the " volume indicator " meter is approximately proportioned to the mean power in the syllable. By comparison with oscillograms, or by equivalent methods, the volume indicator readings can be correlated by absolute quantities. Fig. 10 is an example showing the relation between speech level as measured with the volume indicator and the average instantaneous amplitude of the speech waves on a certain laboratory telephone circuit of the commercial type.

Fig. 11 illustrates the type of data which can be expeditiously secured by means of the volume indicator. Here the levels for a large number of speakers and conversations (over a laboratory telephone circuit of the commercial type) are determined. To cover the same ground by means of oscillographic measurements would have been a decidedly formidable task.

Another device for the rapid measurement of speech levels is the " impulse meter,"† shown in Fig. 12. This is essentially a peak voltmeter. The curve shows the time rate at which the potential on the blocking condenser builds up. The time required for the galvanometer to reach its maximum deflection is determined by the dynamic characteristic of the meter and associated plate circuit, as well as by the time constant of the condenser charging circuit.

In using the volume indicator type of instrument in the telephone plant, limits are observed which have been determined by trial to give satisfactory operating results. The fact that it is possible to set such

* Essential features of this apparatus are shown by E. L. Nelson, U.S. Patent No. 1523827, filed 8-31-22.
† D. Thierbach, *Zs. F. Techn. Physik*, No. 11, 1928.

limits indicates a correlation between mean syllabic power and peak pressures. The overload capacity apparatus is so important that laboratory investigations of quantities affecting it merit more fundamental study than can be made with instruments of the volume indicator type. The quantities of interest are the instantaneous amplitudes of the wave peaks, the frequency of their occurrence and their distribution in the frequency spectrum. The apparatus used to obtain the data described below will be described in detail elsewhere. It is sufficient to state here that it is capable of directly (and automatically) registering the magnitudes and frequency of occurrence of the instantaneous peaks over a range of 60 db, corresponding to a power ratio of 1 000 000 : 1. The peak amplitudes were measured for the whole spectrum and also for restricted frequency bands selected by filters.

Fig. 13 and Fig. 14 show the results of some measurements with undistorted speech. Each individual observation gives the magnitude of the peak pressure in a $\frac{1}{8}$ second interval. This is about as short an interval as one can use and still retain a high degree of probability that the individual measurements will give the maximum peak amplitudes in syllables. Otherwise, from the standpoint of the apparatus, the individual observations could be confined to much shorter time intervals, resulting in many more measurements for a given length of speech. The ordinates give the ratios of the peak pressures to the average total speech pressure. In Fig. 13 the peaks are those of speech as a whole. In Fig. 14 the ordinates give the peak pressures in the several frequency bands. This is done for three widely different average levels spread over a range of 30 db. From the standpoint of providing apparatus overload capacity it is sometimes important to know not only the maximum values of all peaks (which might be uneconomical to provide for) but the upper limit of a certain percentage of all the peaks. The lower half of Fig. 14 illustrates this method of analysing the peak data. It is interesting to note how much larger the transmission capacity must be to take care of the highest 25 per cent. of the peaks.

Fig. 15 gives a similar picture of the peak amplitude distribution in a piano composition, for which the average amplitudes are given in Fig. 7. The microphone was about 7 ft. laterally from the centre of the keyboard, and the measurements were made in a room having an average reverberation of about 1 second.

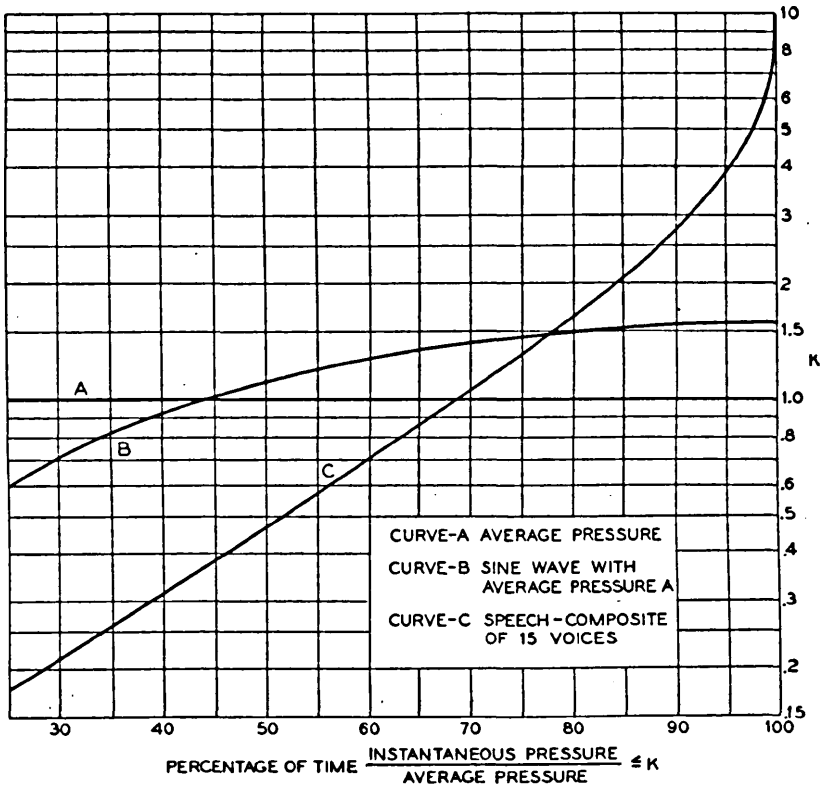


FIG. 2.—Time distribution of speech pressures.

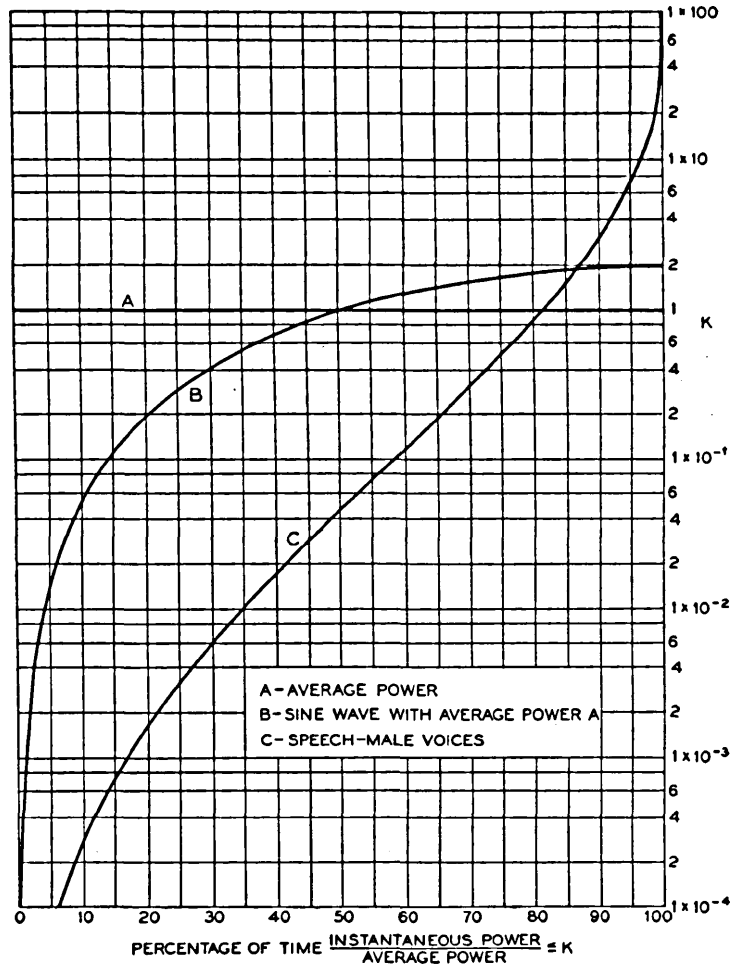


FIG. 1.—Time distribution of speech power.

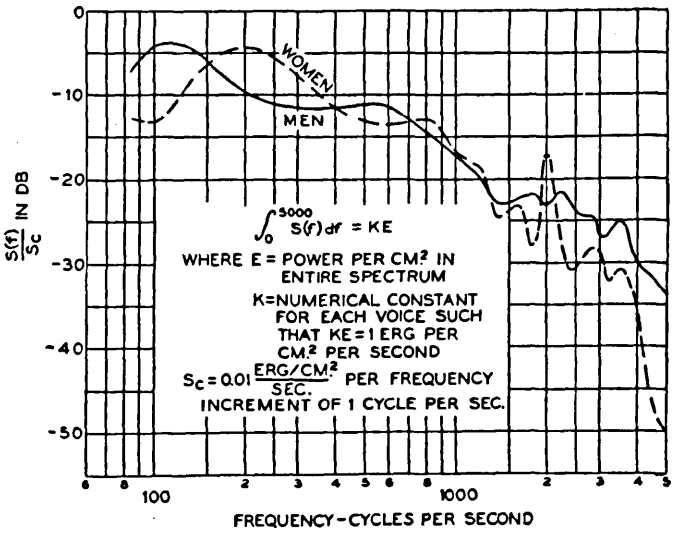

WOMEN
MEN
$\int_0^{5000} S(f)df = KE$
WHERE E = POWER PER CM² IN ENTIRE SPECTRUM
K=NUMERICAL CONSTANT FOR EACH VOICE SUCH THAT KE=1 ERG PER CM² PER SECOND
$S_c = 0.01 \frac{ERG/CM^2}{SEC.}$ PER FREQUENCY INCREMENT OF 1 CYCLE PER SEC.
$\frac{S(f)}{S_c}$ IN DB
FREQUENCY-CYCLES PER SECOND

FIG. 3.—Energy spectrum of connected speech-composite curves for four men and for two women.

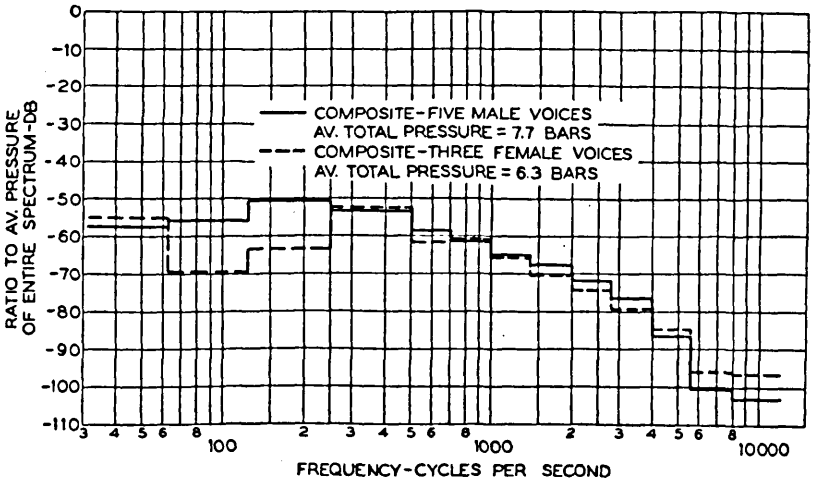

COMPOSITE-FIVE MALE VOICES
AV. TOTAL PRESSURE = 7.7 BARS
COMPOSITE-THREE FEMALE VOICES
AV. TOTAL PRESSURE = 6.3 BARS
RATIO TO AV. PRESSURE OF ENTIRE SPECTRUM-DB
FREQUENCY-CYCLES PER SECOND

FIG. 4.—Average speech pressures per frequency interval of 1 cycle per second—normal conversational voice. Distance 2 inches.

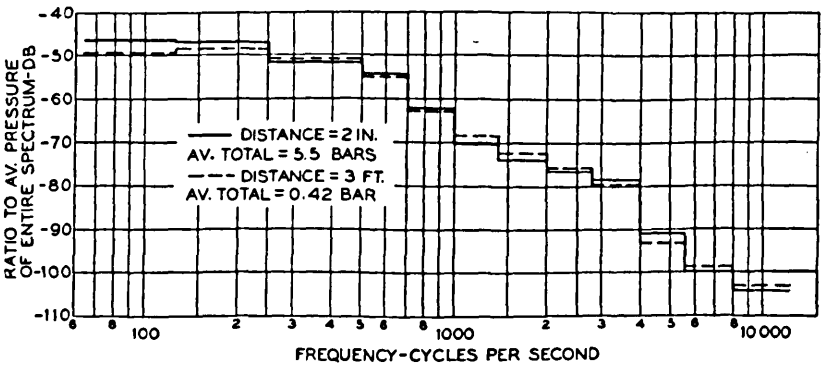

DISTANCE = 2 IN.
AV. TOTAL = 5.5 BARS
DISTANCE = 3 FT.
AV. TOTAL = 0.42 BAR
RATIO TO AV. PRESSURE OF ENTIRE SPECTRUM-DB
FREQUENCY-CYCLES PER SECOND

FIG. 5.—Effect of distance on voice spectrum—average pressure per frequency interval of 1 cycle per second—normal speech-composite, three male voices.

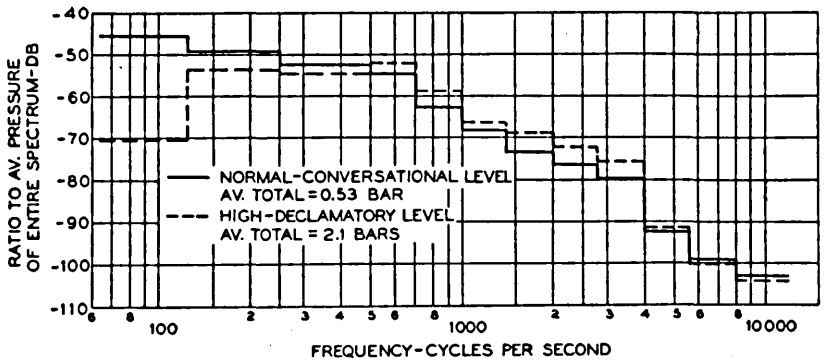


FIG. 6.—Effect of level on voice spectrum—average pressures per frequency interval of 1 cycle per second—composite, three male voices, distance 3 feet.

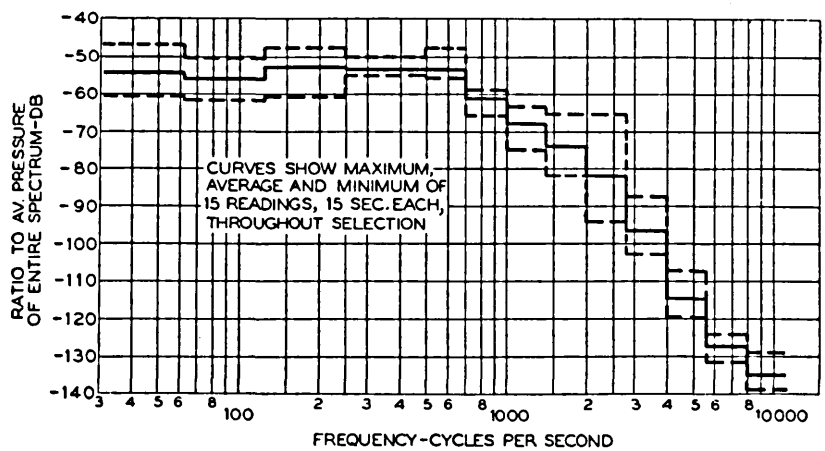


FIG. 7.—Average pressures per frequency interval of 1 cycle per second—piano selection—Liszt's "Hungarian Rhapsody No. 2"—average total pressure=3·5 bars.

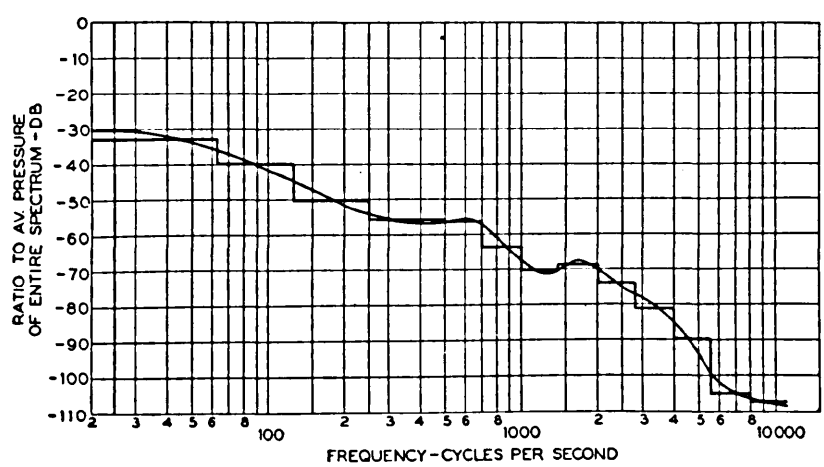


FIG. 8.—Average pressures per frequency interval of 1 cycle per second—street noise—10th floor Bell Telephone Laboratories facing east—2.50—3.20 p.m., 10th October, 1928—average total pressure=0.75 bar.

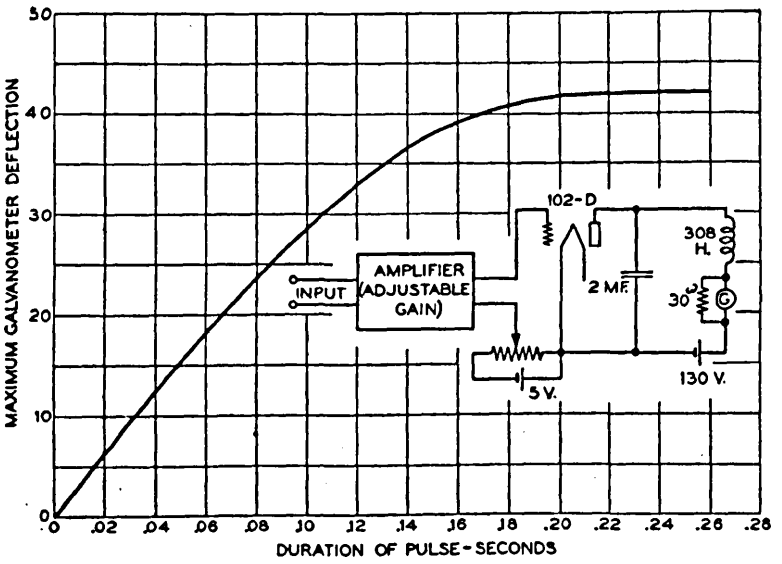


FIG. 9.—Volume indicator—deflection as a function of A.C. pulse duration.

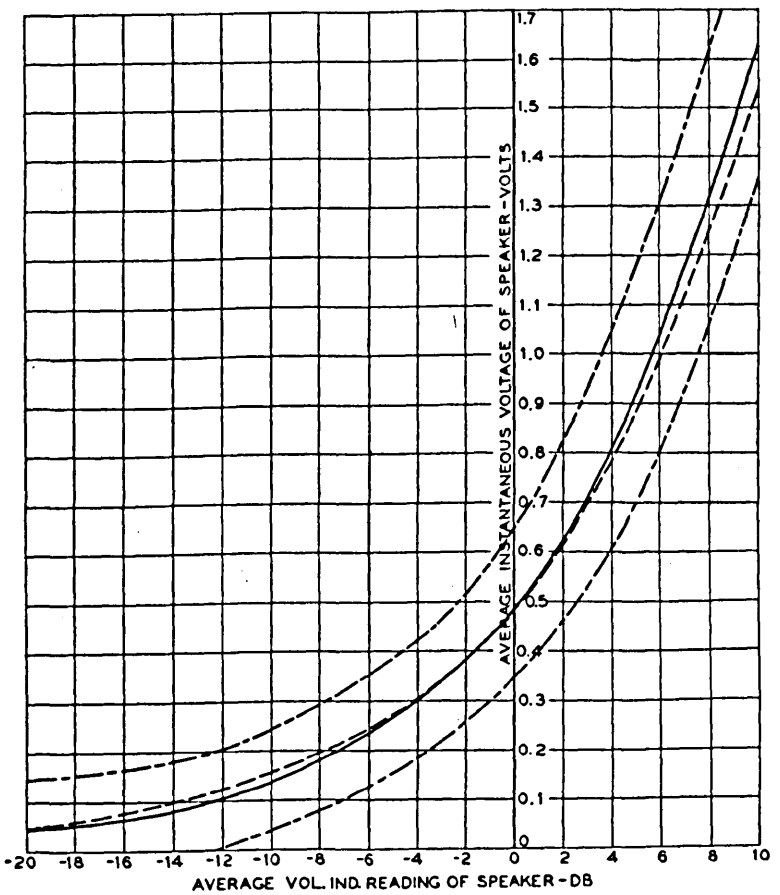


FIG. 10.—Instantaneous voltage V.S. Volume indicator reading 85 per cent. of observed points included between outer dashed curves—ordinates of middle dashed curve are inversely proportional to gain of volume indicator.

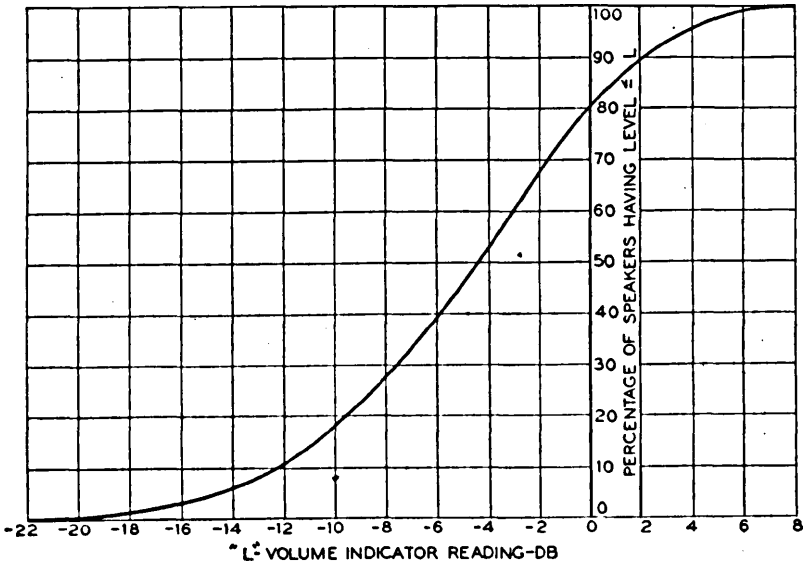


FIG. 11.—Distribution of speaker's levels—87 men and 59 women.

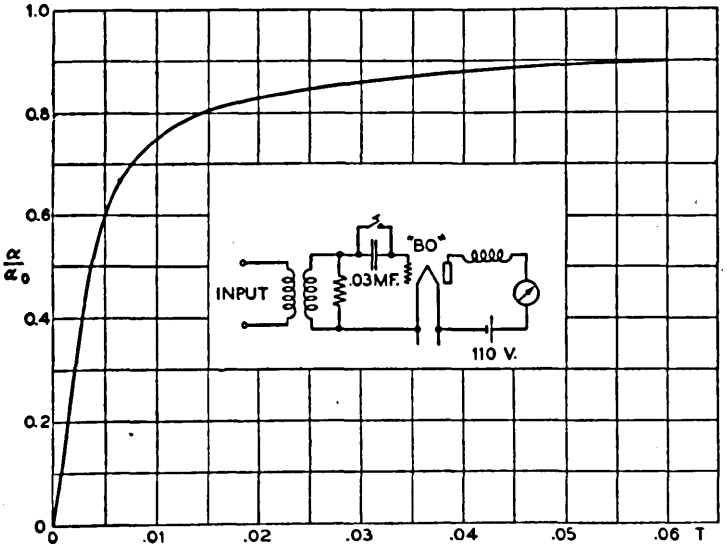


FIG. 12.—Impulse meter.

T = Duration of A.C. impulse
a = Corresponding ultimate plate current.
a_0 = Ultimate plate current for steadily applied A.C.

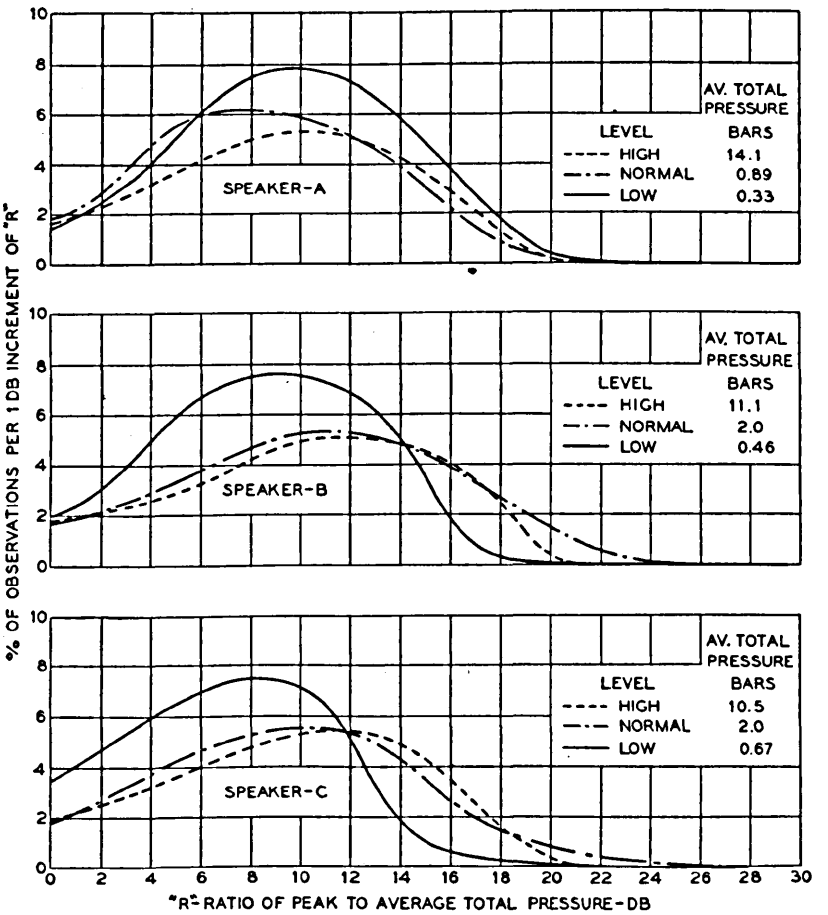


FIG. 13.—Distribution of peak pressures for entire speech spectrum—three male voices—each peak is the maximum instantaneous pressure during $\frac{1}{8}$ sec.

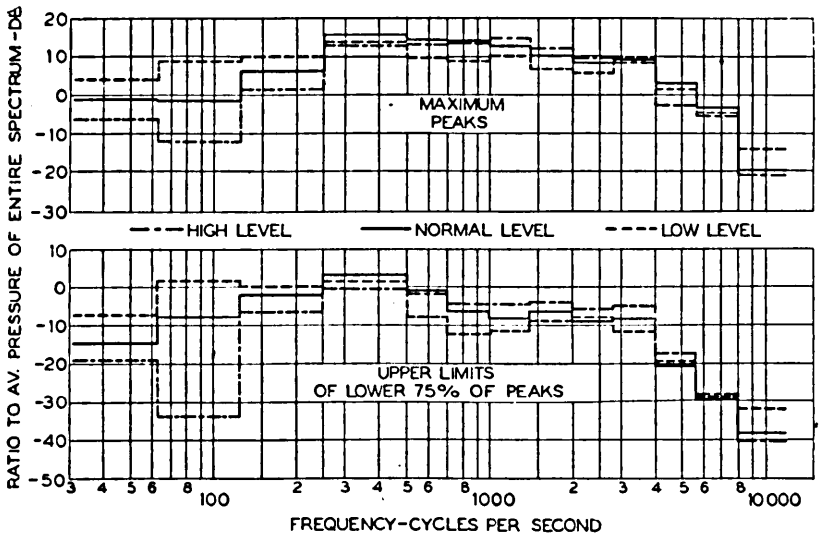


FIG. 14.—Peak pressures of speech—composite, three male voices—each peak is the maximum instantaneous pressure during $\frac{1}{8}$ second—average total pressure:

High (declamatory) level—8.7 bars;
Normal (conversational) level—1.6 bars;
Low (confidential) level—0.5 bar.

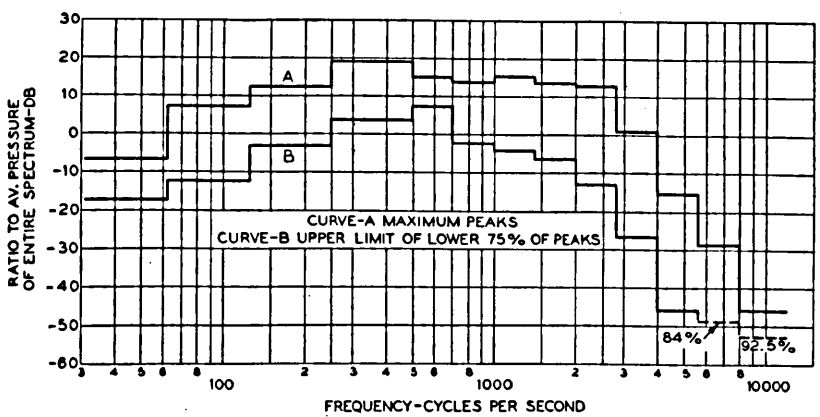


FIG. 15.—Peak pressures in piano music—Liszt's "Hungarian Rhapsody No. 2"—each peak is the maximum instantaneous pressure during $\frac{1}{8}$ sec.—average total pressure 4.0 bars.

APPENDIX V.

CONCERNING QUESTION No. 1 OF THE FOURTH COMMISSION OF RAPPORTEURS. SPEECH POWER AND ITS MEASUREMENT.

Memorandum of the American Telephone and Telegraph Company, dated 4th September, 1931.

At the meetings of the Commissions of Rapporteurs of the C.C.I. at Prague (June, 1931), there was some discussion of the power represented by speech and the variation of this power as between different speakers and between different instants of time. This memorandum gives some data based on fairly extensive measurements by the Bell Telephone Laboratories.

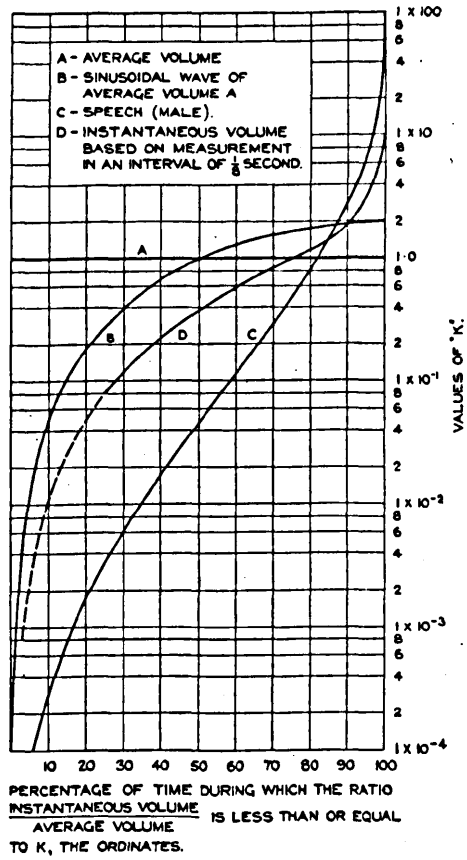


FIG. 1.—Time distribution of speech power.

Speech power fluctuates rapidly, and the deviations from the average value vary considerably depending on the characteristics of the voices involved. Fig. 1 attached shows for a group of male voices (Curve *C*) the deviation of the instantaneous power defined as the integrated power during an interval of 50 microseconds (which almost corresponds to an instantaneous power) from the average power plotted as a function of percentage of time during which the ratio of the two powers is less than the ordinate. This curve was obtained by a large number of random measurements taken on continuous practically undistorted speech by means of a measuring device which measured nearly instantaneous values. The principle of the device is to measure the charge of a condenser after contact with the circuit in question. The measuring apparatus was so arranged that the condenser could be removed from the speech circuit in less than 50 microseconds, making the measurements practically instantaneous. Measurements were also made to give the average speech power over $\frac{1}{8}$ second time intervals taken at random instead

of instantaneous intervals as above. Curve *D* of Fig. No. 1 shows the data obtained for measurements of this kind on continuous undistorted speech.

The curves of Fig. 1 were taken at a constant volume level as measured by the volume indicator, the amplification of the apparatus being adjusted to give the same volume level at the point of measurement with the different speakers. There is, however, a wide variation in the volume level of speech for different speakers. This variation is indicated by the data in Fig. 2. This curve is based on measurements with the volume indicator which has a building up time of about 0.2 second, corresponding to the

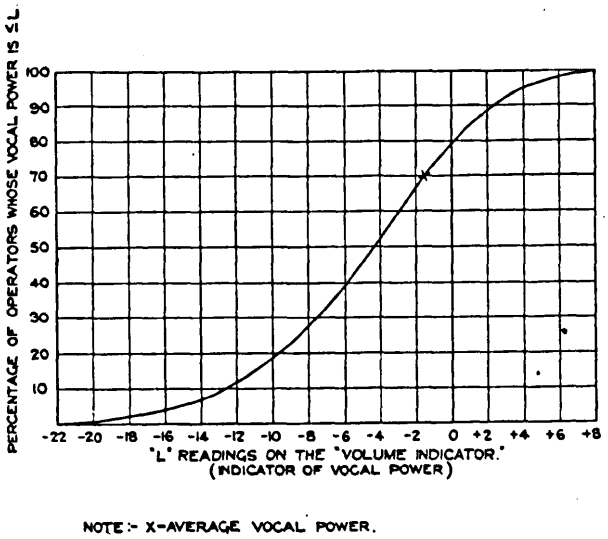


FIG. 2.—Distribution of speaker's levels—87 men and 59 women.

average syllable duration, so that the maximum deflection is approximately proportional to the mean power of the syllable. It will be noted that this curve shows a spread of average volume between different speakers of 30 db, 90 per cent. of the readings, however, being within a range of about 20 db. The average acoustic power of the voice corresponding to the zero point on this curve is approximately 14.5 microwatts when integrated over the entire talking period, or 21.7 microwatts when integrated over the duration of the syllables alone. This is 1.6 db higher than the average indicated by the curve.

The combination of the data given in Figs. 1 and 2 gives an indication of the probable variation in power of speech sounds with various speakers, and for various percentages of the talking interval.

APPENDIX VI.

REFERRING TO QUESTION No. 2 OF THE FOURTH COMMISSION OF RAPPORTEURS.

Test methods to be used to determine, in terms of transmission units, the value of the impairment in the quality of transmission, due to a restriction of the frequency band effectively transmitted, or due to noise.

The test methods, already used by various Administrations and Operating Companies and which were recommended for continued use by the Plenary Meeting in Paris, 1931, are as follows :—

A.—To determine impairment of transmission due to noise.

Three test methods may be used to evaluate, in népers or decibels, the impairment in the quality of transmission due to noise.

All three methods are in use in the United States of America and one of them is used in other countries (notably Great Britain and Germany).

(1) Method based on articulation tests.

The articulation is determined for different values of noise introduced in a given circuit (a test circuit with a constant reference equivalent, e). An articulation curve is plotted as a function of the noise. The reference equivalent of the test circuit is then increased above e, and the articulation curve is plotted as a function of the increase in the reference equivalent, the test circuit having been silent during this test.

Comparing the two curves, it is possible to determine the increase in the reference equivalent which reduces the articulation to the same extent as a noise of a given volume and frequency—that is to say, the value in transmission units of the impairment in the quality of the transmission due to a given noise. For these tests it is necessary to use the apparatus recommended by the C.C.I for objective noise tests, and to have available a source of suitable noise, the test results being dependent on this apparatus. As an example, the source of noise used in such tests in the United States of America is described in the second addendum to the Appendix (*q.v.*).

(2) Estimating method.

A typical test circuit is used and a switch is employed, by means of which it is possible either to vary the attenuation or to introduce noise. A sufficiently large number of observers (one hundred, for example) are asked to compare the transmission over the test circuit for the two positions of the switch. Their estimate will indicate if the test circuit with noise introduced is, from a transmission standpoint, equal to, better or worse than the silent test circuit, the attenuation of which has been increased to a definite value. When, for a given noise, an attenuation value has been obtained such that the number of favourable and unfavourable opinions are equal in number, it is considered that the increased attenuation is a measure, in transmission units, of the impairment in the quality of the transmission corresponding to the noise considered.

(3) Method by observing repetitions.

A test circuit with a given reference equivalent is used, over which conversations are held, during which the number of repetitions on the part of one or the other of the speakers is observed over a sufficiently long period (for example, 50 000 or 100 000 seconds).

The number of repetitions per 100 seconds is noted and this number is called the " repetition rate."

By increasing the attenuation of the circuit or by introducing a noise of given frequency and increasing volume, one may plot :—

(*a*) A curve of repetition rate as a function of noise.

(*b*) A curve of repetition rate as a function of increased attenuation.

It is then possible, by means of these curves, to determine in transmission units the increase in the attenuation which produces the same variation in the rate of repetition as a noise of given volume and frequency.

When the method based on articulation tests is used, it is necessary to take the same precautions as in ordinary articulation tests.

When the method by observing repetitions is used it is necessary to ascertain that all variable factors which may influence the test results have similar values throughout the various tests, with the exception of the factor which is to be determined—that is to say, in this case, the artificial line noise.

The factors which should be particularly considered are: the restriction of the frequency band effectively transmitted (distortion), the non-linear distortion of lines and apparatus, the local effect, room noise, the extent to which the two speakers are familiar with the language used.

The third method (observing repetitions) is the most practical criterion and, if the necessary precautions are taken, the results obtained are to be given preference over those obtained by other methods.

By objective noise measurements (using a vacuum tube voltmeter equipped with a filter which suitably weighted each frequency component, an instrument graduated in decibels, the zero point of

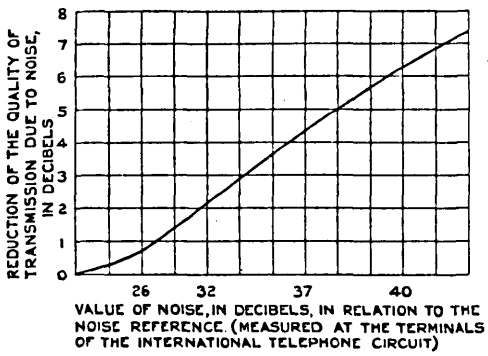


FIG. 1.—Reduction of quality of transmission due to line noise (U.S.A.) (Average room noise and a transmission system from 18-30 db.)

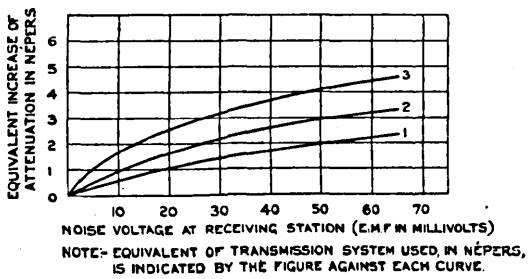


FIG. 2.—Reduction of quality of transmission due to line noise (German).

which corresponded to a power of one microwatt at 1000 p : s, this being the calibrating frequency of the instrument) the American Telephone and Telegraph Company has obtained the curve shown in Fig. 1.

The German Administration (using apparatus for objective noise tests, known as a Noise Voltage Indicator, graduated in volts and expressing in millivolts at 800 p : s, the noise equivalent after filtering) have obtained the results shown graphically in Fig. 2.

B.—To determine the impairment in the quality of transmission due to the restriction of the frequency band effectively transmitted.

Administrations and Operating Companies making such tests may wish to avail themselves of the methods indicated below:—

The method based on articulation tests and the method by observation of repetitions indicated above may be adapted for use in determining the impairment in the quality of transmission due to a restriction of the frequency band effectively transmitted, if the variable introduced is the width of the frequency band effectively transmitted, rather than the noise.

According to the recommendations of the C.C.I. a frequency is effectively transmitted if the attenuation of that frequency differs from 800 cycle attenuation by less than 1 néper or 8.7 decibels. In the

United States this definition is valid, except that it is expressed as 10 decibels at 1000 p:s, which is practically the same.

It appears to be more difficult to apply the Second Method, known as "estimating," to determine the impairment in the quality of transmission due to a restricted frequency band being effectively transmitted.

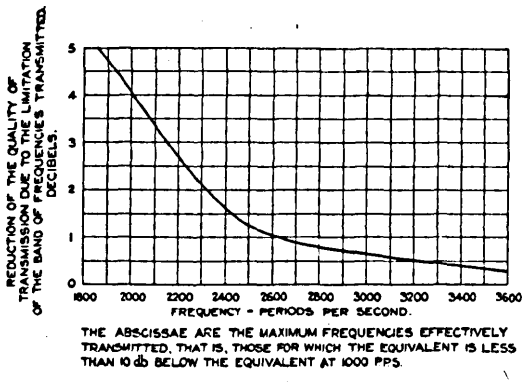


FIG. 3.—Reduction of quality of transmission due to the limitation of the band of frequencies effectively transmitted (U.S.A.). (Average room noise, equivalent of transmission system used, 18-3 db.)

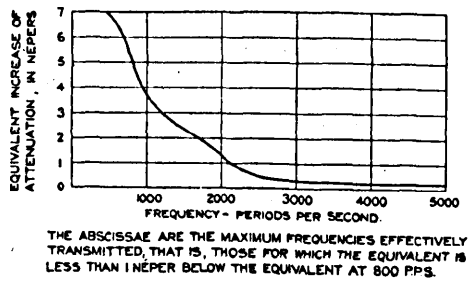


FIG. 4.—Reduction of quality of transmission due to the limitation of the band of frequencies effectively transmitted (German).

As an example, the American Telephone and Telegraph Company, concurrently using the methods of articulation tests and observation of repetitions on a long-distance circuit terminated with commercial instruments, gives the results graphically reproduced in Fig. 3.

Similarly, the German Administration have obtained the results shown in Fig. 4.

Note.—The exact conditions, under which the tests yielding the results shown in Figs. 1 to 4 were conducted, are given in the first Addendum to Appendix VI.

FIRST ADDENDUM TO APPENDIX VI.

REFERRING TO QUESTION No. 2 OF THE FOURTH COMMISSION OF RAPPORTEURS.

FIRST PART.—Memorandum of the American Telephone and Telegraph Company, dated 30th June, 1931, concerning Noise Transmission Impairments and Distortion Transmission Impairments—Circuit and Noise Conditions.

If values of Noise Transmission Impairments and Distortion Transmission Impairments for field use are to be determined by making articulation tests in the laboratory, it is important that the circuit and the room and line noises used be typical of commercial conditions. The reason for this is that the magnitude of volume change from some specified condition, which reduces articulation the same amount as a reduction in the width of the band of frequencies transmitted or an increase in the amount of line noise, has widely different values depending upon the specified reference condition. For example, in the case of line noise, the impairment (in db) due to any ordinary value of line noise in the absence of room noise may be several times the impairment in the presence of average amounts of room noise. In the same way, the impairment in db caused by lowering the upper cut-off frequency of a toll line may be much larger with no room and line noise than it is with average conditions in these respects. The large values of the transmission impairments determined in the absence of room and line noise are due to the fact that under these conditions on ordinary commercial circuits, and within the range of talking levels ordinarily used, the received volume is near the optimum value from which large reductions in volume are necessary before any appreciable reduction in articulation is noted. Under commercial conditions as regards room and line noise, the margin of the received speech over the noise is small, and large changes in articulation are obtained with small changes in volume.

The Distortion Transmission Impairments and the Noise Transmission Impairments which are in use in the Bell System (shown in Figs. 1 and 3) have accordingly been based on commercial conditions. These conditions are as follows :—

(*a*) **Circuit.**—No. 337 transmitters, No. 144 receivers, No. 46 induction coils, standard connection, three-mile 22 B & S gauge loops (0.64 mm), 25-A repeating coils, 48-volt battery, M-88 loaded switching trunks, each of 2.5 db equivalent, and a distortionless line of 13 db giving an overall volume equivalent of about 25 db.

(*b*) **Speech.**—An average talking level corresponding to a volume indicator reading of —13 db at the input to the distortionless trunk for the above circuit condition was used.

(*c*) **Line Noises.**—Average amounts of noise from toll line, switching trunks and loops were used in arriving at our distortion transmission impairments. The values of the individual noises were such that the total noise in the receiver if measured with the circuit noise meter would be of the order of 27 db above reference circuit noise. (The noise reference corresponds to 1 micro-microwatt at 1000 periods per second in a circuit of 600 ohms.)

(*d*) **Room Noise.**—The room noise to which our impairment figures apply is of the order of the average noise at business locations, or roughly 400 noise units as measured by our old balance method, in which the noise from a noise standard, brought to a telephone receiver on one ear, is adjusted to be as loud as the room noise in the other ear, as described in the Second Addendum to Appendix VI. A typical room noise of such a value would be of the order of 45 db above the threshold of hearing.

For making tests to determine noise or distortion transmission impairments for European conditions, it is suggested that noises typical of the conditions encountered in Europe be used.

It is further suggested that phonographic records of both room and line noise be obtained, and that these records be used for producing the noises in the tests.

SECOND PART.—Note by the German Telephone Administration on the results of measurements of impairment in the quality of transmission (due to noise or restriction of the frequency band effectively transmitted) and the results shown graphically in Fig. 2 and Fig. 4 above.

In the memorandum of June 30, 1931, by the American Telephone and Telegraph Company, the conditions under which the American results were obtained are clearly defined. It is particularly evident that they have endeavoured to determine the influence of the frequency band restriction when disturbing noise is present. During the measurements made in Germany we have not followed that method, but rather worked along the line of finding the effect of each cause separately.

We have thus determined the quality of transmission, either during the presence of room or line noise, or with an artificial restriction of the frequency band effectively transmitted. In the study of the effect of frequency band restriction or of disturbing noise the attenuation used was 1 néper ; the reference equivalent of the whole transmission system was 2 népers. The effect of the frequency band restriction was studied with noise eliminated (and, conversely, the effect of noise was studied under conditions of non-distortion). The apparatus used was the standard common battery type of the German Administration.

Comparative measurements have shown that the test results depend very largely on the conditions under which the tests are made. For example, the effect of the noise is very different for different degrees of attenuation. Among the data collected in Germany in the course of this study are curves corresponding closely to the conditions which obtained in the American tests. The German curves have been compared with the American ones and it has been found that they do not agree. The experience so far gained

has shown that the results of these measurements are very uncertain. It appears, therefore, that the question of determining the quality of transmission by means of equivalent attenuation is not ripe for an international agreement beyond the fact that the results show clearly that it is not possible, for example, to equate a disturbing noise to a corresponding reduction of transmission efficiency.

SECOND ADDENDUM TO APPENDIX VI.

REFERRING TO QUESTION No. 2 OF THE FOURTH COMMISSION OF RAPPORTEURS.

Noise Standard used in the United States of America for comparative tests to determine the impairment of quality of transmission due to noise.

General.—The method of subjective measurement of noise in a telephone circuit, which has so far proved very useful, consists in comparing the sound produced in a telephone receiver connected to the circuit under test, with the sound produced in the same receiver when connected to an adjustable source of noise (known as the " noise standard "). The receiver is switched between the telephone circuit and the noise standard, the volume of the artificial noise being adjusted until the observer estimates that the circuit noise and the artificial noise have the same effect on a telephone conversation so far as the reduction of articulation is concerned. The number of conventional units of artificial noise (noise units) which correspond to the balance thus obtained is taken as a measure of the noise in the circuit.

The noise standard consists of a vibrator, which is the source of the noise, and a shunt, by means of which the artificial noise can be regulated.

The graduations on the shunt indicate the number of noise units, corresponding to the current, flowing through the receiver for each setting of the shunt. A key is used to connect the telephone

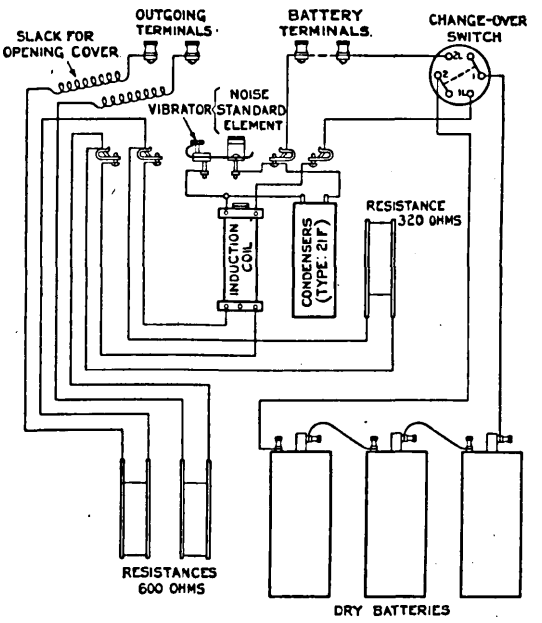


FIG. 38-Y-954.

receiver alternately to the circuit and, through the shunt, to the source of noise. Another key permits the testing of noise on a metallic circuit or between the wires and earth, as required.

DESCRIPTION OF NOISE STANDARD.

Fig. 38-Y-954 is a diagram of the apparatus and connections of the source of noise. It consists of a vibrator (noise standard element), three dry cells, an interruptor to open and close the battery circuit,

and two resistances in series with the output terminals of the apparatus, and in parallel with the secondary winding of the induction coil associated with the vibrator.

The primary winding of the induction coil is connected in series with the vibrating reed and the dry cells, whilst the secondary winding, connected to the output terminals, is the source of noise. A condenser is connected across the contacts of the vibrating reed to reduce sparking. The vibrator is a separate unit, which may readily be disconnected from the source of noise. The vibrating reed is adjusted by the makers and is then sealed; in case it does not operate properly, no attempt should be made to readjust it.

The battery circuit is only closed when the telephone receiver used in the test is connected to the source of noise.

A pole changer is fitted to the apparatus to reverse the polarity of the battery between the fixed contact and the vibrating reed in order to prolong the time during which the vibrator may function without serious wear on the contacts. The pole changer should be operated every hour or every half-hour in order to equalise the operating time for each polarity. The vibrator will not operate indefinitely, but, if the batteries are well maintained, it should function with sufficient constancy for at least 200 hours of ordinary (intermittent) service.

In order to avoid a variation in the load on the source of noise the total resistance of the connection between the shunt and the source should be about 0.15 ohm for the two wires. Cord No. 650, furnished with the apparatus, has that resistance. If this cord is not available one may use 30 feet of No. 14 B. & S. (1.63 mm) fixture wire. The dry cells should last 6 to 10 hours (intermittent service) before replacement. They should be replaced as soon as the voltage falls below 1.25 volts per cell. They should likewise be replaced if a noticeable variation is observed in the volume, quality or frequency of the noise, or when the vibrating reed fails to start when the interruptor is closed.

APPENDIX VII.

REFERRING TO QUESTION No. 10 OF THE FOURTH COMMISSION OF RAPPORTEURS.

A Survey of Room Noise in Telephone Locations

By W. J. WILLIAMS and RALPH G. MCCURDY.

(*Article published in the "Bell Telephone System Technical Publication," October*, 1930, "*Monograph B-526.*")*

This paper describes a survey made to determine the range of magnitudes of room noise present in telephone locations. Measurements were made in a total of 250 locations in New York City and environs, distributed among businesses and residences in accordance with telephone traffic distribution. In each location, measurements were made by a marginal audibility method using the human ear as a part of the measuring device, and by a visual indicating meter. A brief description is included of the apparatus employed with each of these methods. Results are presented for measurements made in various classes of rooms, under winter and summer conditions.

Among the projects of the Joint Sub-Committee on Development and Research of the National Electric Light Association and Bell System is one (No. 4) which is studying the effects of noise† on telephone transmission and methods for it measurement. It was appreciated that, in addition to noises of electrical origin caused by exposures to power circuits or by sources incidental to the operation of the telephone system, there are also noises in the rooms in which telephones are used which have an

* *See* pp. 340-342 for the Figs. referred to in this article.

† In this joint work, noise is taken to mean any extraneous sound which would tend to interfere with telephone conversation.

Room noise is used to include any extraneous sounds at the place where the measurement is made, except those proceeding from the telephone receiver. It thus includes, in addition to noises such as the rattling of papers or the roar of street traffic, any other sounds extraneous to the telephone conversation, for example, those of other conversations or of music produced nearby.

important effect on telephone service. In studying the effects of noises, it is, of course, necessary to consider both noises of electrical origin and room noises. It was desired that, in laboratory tests of the effects of line noises on speech transmission, typical amounts of room noise should be provided at the test location. The survey described herein was made to obtain room noise data for these laboratory tests.

The methods described should be of general interest in connection with other noise problems. Increasing attention is being given, both in America and in Europe, to the general problem of noise as an undesirable attribute of modern civilisation. Some efforts are being made to investigate sources of city noise. Modifications have been made in the design of machines and appliances, such as typewriters, motor cars, electric refrigerators, rotating electrical machinery, and domestic oil burners, so as to reduce the noise involved in their operation. Attention is being given to the quieting of rooms by means of acoustic treatment. Studies are being made of the effects of noise on living beings including effects on the efficiency of workers.* In all of this work, quantitative measurement is important.

For the specific problem in hand, it was desired to obtain information on the magnitudes of room noises, as well as some general indication of the frequency composition of typical room noises.

While it is recognised that ordinary room noise is a highly variable quantity, changing from instant to instant in intensity and frequency composition, it is felt that sufficient measurements were made to specify the make up of a typical room noise for use in the laboratory tests, and in addition to obtain an indication of the effect of various factors, described below, upon the noise. Since it was desired to make the measurements as representative as possible of typical telephoning conditions they were made at times of day and in types of locations determined by a study of telephone message traffic. Since the results would be affected by the choice of locations, they are presumably less typical for non-telephone than for telephone purposes.

The residences included in the survey ranged from apartments in large city buildings to small homes in outlying towns. In the business locations were included offices, stores, factories and workshops, and public buildings, such as hotels and clubs.† Establishments of various characters were included in each classification; they ranged in size from small stores to great manufacturing plants.

In making all measurements, an attempt was made to simulate the normal conditions which would obtain when a telephone call was placed. If noises existed in the room, which would be discontinued when the telephone was being used, such noises were stopped while the measurements were being made. On the other hand, care was taken to see that none of the normal noises of a particular location was discontinued because of the fact that measurements were being taken.

It was recognised that there would be a difference between the room noise experienced on local and on long-distance calls. The survey was made on the basis of telephone traffic as a whole, which consists predominantly of local calls.

The survey consisted of two series of tests, one made during the months of January, February, March and April, and the other made during the months of July and August. The former series was the more comprehensive, including 205 measurements; the results given herein are based on this series of tests except where specifically noted otherwise. The second series of tests was made for the purpose of determining the difference between the room noise encountered under winter conditions and that encountered under summer conditions. Consequently, a selected group of the locations which had been measured in the winter, were measured again under summer conditions.

It must be appreciated, in generalising from the data given, that tests were made in only a limited number of locations.

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* D. A. Laird, "The Effects of Noise," *Jl. Acoustical Soc. Amer.*, January, 1930, p. 256.

† In public buildings, only a very small proportion of the telephone locations tested were in booths or at coin-box telephones.

Two methods were employed in making the measurements described in this paper, one electrical and the other aural. The electrical method employed a condenser-transmitter pick-up, amplifiers, and detector. A weighting network was incorporated in the amplifier to simulate the sensitivity characteristic of the ear. The aural method, known as the "masking method," involved the measurement of the masking effect of the noise on various warbler tones recorded on a phonograph record. Both of these methods will be described in greater detail below.

General Results.

Some of the interesting results which were obtained from this survey may be summarised as follows :—

On the average, room noise in residences was about 20 db less in magnitude than that in business locations.

The spread in the magnitudes of business room noises was about 40 db, as compared to 20 db for residence room noises. These spreads include 90 per cent. of the measurements, excluding the lowest and highest 5 per cent. The standard deviation of the measurements was about 12 db for business noise and 6 db for residence noise.

Room noises averaged 4 or 5 db higher in summer than in winter.

In general, the magnitude of residence noise was affected to only a minor extent by the size of the town or city in which it was measured.

On the average, the frequency composition of residence noise was about the same as that of business noise. The masking effect of the noise on a tone covering the range 750-1500 cycles was greater than that on ranges above and below this. The magnitudes of components in the lower part of the range covered (about 250-5000 cycles) appeared to be somewhat larger than those in the higher part of this range.

METHODS OF MEASUREMENT.

The two methods which were employed in the survey are as follows :—

Aural Method—Masking of Warbler Tone*—In this method a tone of varying pitch (warble) is produced and sent into a receiver. The receiver cap is provided with slots shaped so that the observer's ear canal is always open to the air of the room regardless of how firmly the receiver is pressed against the ear. The tone is generated by means of a phonograph record and a magnetic phonograph record pick-up, and is a variable-frequency tone, the pitch of which varies between certain limits several times per second. An attenuator is placed between the magnetic pick-up and the receiver. The observer sets the attenuator at a point where he can barely recognise the sound of the warble in the presence of the room noise. He also obtains the setting at which he can barely hear the warble in a perfectly quiet room. The difference between these two settings is a measure of the masking effect of the noise in this room upon the warbler tone, for this particular observer.

An idea of the frequency composition of a given room noise may be obtained by using several different warbler tones, each covering a different portion of the voice-frequency range. This is based on the fact, that, in general, a tone of a given frequency masks to a greater extent tones that are near it in frequency than tones that are far removed from its frequency.

The phonograph records used in the present room noise survey were three-band records, *i.e.*, three warbler tones were cut on each record, each tone occupying about one-third of the available space. The frequencies included in the various bands were as follows : high band 1500-5600 cycles per second, middle band 750-1500 cycles per second, low band 250-750 cycles per second. In each band the

* R. H. Galt, *Jl. Acoustical Soc. Amer.*, October, 1929, p. 147.

frequency varied continuously from the lower to the upper limit and back to the lower limit, the period of such a complete "warble" being about one-sixth of a second.

Electrical Method—Room Noise Meter.—There is, of course, a number of different electrical methods which might be employed for measuring room noise, ranging from a single over-all measurement to a complete wave shape or frequency analysis. The complete analysis or the measurement of energy present in a considerable number of narrow frequency bands is subject to the disadvantages, for such a survey as this, of slowness of measurement and bulkiness of testing equipment.

The method which was adopted was one based on the use of a frequency weighting simulating the sensitivity of the ear. This frequency characteristic is shown in Fig. 1. It is an equal loudness weighting; that is, the room noise meter was so constructed that different single-frequency noises of equal loudness would give approximately the same meter readings. The shape of an equal-loudness curve is somewhat flatter for high levels of loudness than for low ones. The weighting curve chosen for the meter was for a loudness corresponding to that of a 1 000-cycle tone 30 or 40 db above the threshold of audibility. This general level is not far from the middle of the range of levels of room noise components. The loudness data used were those given by Kingsbury,* based on experimental data on single-frequency tones.

The sensitivity of the meter is such that a 1 000-cycle tone about 28 db above threshold would give a reading of 0 db on the meter scale.

The room noise meter employed is shown together with its auxiliary equipment in Fig. 3. It consists of a condenser transmitter for converting acoustical energy into electrical energy, six stages of amplification for raising the level of the noise currents sufficiently to operate a thermocouple meter indicating device, and a weighting network, as described above, as well as certain apparatus not employed in obtaining the results reported here. The general layout of the circuit is indicated in the schematic diagram of Fig. 2. A portable battery supply and means for calibrating form the necessary auxiliary equipment. An adjustable attenuator controlled by a key and a dial is provided between stages of the amplifier so that the noise energy being measured may be brought within the range of the meter over a range of levels of 80 db (corresponding to a power range of 100 000 000 to 1).

Operation of the Room Noise Meter.—The noise meter is first calibrated, as described below, so that its sensitivity is set at a predetermined value. The condenser transmitter is then placed at the spot where it is desired to measure noise, and the gain of the amplifier is adjusted by means of a key and dial until the needle of the microammeter in the output circuit fluctuates about a given point. The settings of the key and dial then give a measure of the noise. In addition to the average readings obtained in this manner, readings of the fluctuations in the noise can be similarly obtained. As an aid in the reading, the microammeter scale is calibrated in decibels.

The calibration of the meter in the field consists of a check on the over-all sensitivity of the instrument. The filament currents and plate voltages are adjusted to the correct values. Then a fixed percentage of the electrical output of a standard buzzer, the current from which is measured by a thermocouple, is fed into a special receiver which is placed in a prescribed way on the condenser transmitter. The gain of the amplifier is then adjusted until the output microammeter needle reaches a predetermined point. The sensitivity of the meter will then be as shown in Fig. 1.

An over-all calibration of the meter, as a function of frequency, is given in this figure. To obtain this, separate determinations were made of the volts generated by the condenser transmitter per unit of pressure, and the meter reading per volt generated by the transmitter, as a function of frequency; and the results were combined to give the values shown. Harmonics in the testing waves were reduced to such a point that they did not affect the results. After a substantial part of the survey had been com-

* *Physical Review*, Vol. 19, April, 1927, pp. 588-600.

pleted, a check was made of the electrical portion of the calibration, and the changes found were quite negligible.

Accuracy of the Meter.—The precision of the apparatus is substantially greater than the precision with which ordinary varying noises can be measured. The readings obtained for steady inputs are proportional to the input, with an error of less than ½ db, over the entire range of noise amplitudes found in the survey. The apparatus is shielded electrically. In only one case did electrical fields produce any observed errors in the readings; this was when an attempt was made to measure the room noise near a rotary converter in a power station. The vacuum tubes are mounted in such a way that the effects of ordinary mechanical vibration on the readings are negligible.

Comparison of the Two Methods.—In general, the meter method gives results in physical terms while the masking method gives them in terms of effects on the ear; consequently, the choice of the method to be employed in any particular case depends somewhat on the use to which data will be put. It is true that the meter includes a network to simulate the sensitivity of the ear for various frequencies; it does not, however, simulate other properties of the ear, such as the departures from linearity in response by which subjective tones are produced by the ear mechanism, and the complicated way in which one sound masks another.*

The meter method, unlike the masking method, avoids any errors due to variations in human ears. This advantage is offset to some extent by the fluctuations of the meter needle, which make it difficult to obtain the mean reading if the noise is unsteady as is the case with most room noises.

In the case of noises of a distinctly intermittent, staccato character, the warbler tone can be heard and recognised in the brief intervals when the noise is a minimum. A preliminary investigation showed that, for a noise of this sort, the relation between readings obtained by the masking method and by the meter method was different from the relation obtained for a steady noise, the warbler readings being relatively lower in the case of intermittent noise.

Both methods were used in the survey, because it was felt that each gave information which could not be accurately obtained from the other, and also because the use of two methods enabled each one to be used as a check upon apparatus defects which might occur in the other.

In using the masking method, data were taken by two experienced observers and corresponding measurements averaged. All meter measurements were made by one observer.

Results of Survey.

Noise in Business Locations.—One hundred and nine business locations were visited. The magnitude of the noises measured varied from that found in a doctor's quiet office to the din of a large manufacturing plant. Distribution curves for the noises measured are shown in Fig. 4 for the meter method and Fig. 5 for the masking method. For any point on one of these curves the corresponding per cent. of all of the measurements made had values equal to or greater than the indicated abscissa value.

It may be seen that with the exception of the "high" curve of Fig. 5 the curves for meter and masking methods are fairly similar in shape. The "middle" curve has been selected to represent the masking method.

If there are excluded as extremes those noises which were so low that 95 per cent. of all the noises measured equalled or exceeded them, and those which were so high that only 5 per cent. of the measurements equalled or exceeded them, the spread of noise magnitudes is seen to be about 40 db. The standard deviation of the measurements is about 12 db.

As shown in Figs. 4 and 5 the median business room noise would produce a reading of 23 db on the meter scale and a masking of 27 db on the high frequency warbler tone, 39 db on the middle-frequency

* R. L. Wegel and C. E. Lane, "Auditory Masking and Dynamics of the Inner Ear," *Physical Review*, February, 1924.

tone, and 31 db on the low-frequency tone. The average business room noise was about 2 db higher than the median.

Some conception of the amounts of noise represented by these figures may perhaps be gained from the following. The extremely loud noise measured in a local station of the New York subway while an express train was passing produced a meter reading of 70 db, while the lowest noises measured in the survey, in quiet residences, gave readings near 0 db.

Data on noise at the business locations tested have been grouped so as to show the average differences in the room noise values obtained for different types of business and for different sizes of towns. It will be appreciated that only a very small number of measurements were included in each sub-classification, and that consequently it is not safe to generalise from these sub-groupings as to room noise conditions in general.

Averages of the room noise measurements for the different types of business locations are shown in the following table.*

Type of business location.	Masking of middle-frequency tone.	Meter reading.	Number of measurements.
	db	db	
Offices	42	24	34
Stores	34	18	34
Factories	57	40	18
Public buildings	35	21	23
Average of all businesses (weighted according to number of measurements made)	40	25	109

The above figures show a significant difference between the noise measured in factories and that measured in other types of location. The other differences shown were found not to be significant when examined in the light of the spread in values for individual locations in each class.

Averages of the business room noise measurements obtained in various sizes of towns are shown in the table below.

Size of town.	Masking of middle-frequency tone.	Meter reading.	Number of measurements.
	db	db	
Class A (over 400 000 pop.) ...	45	26	39
Class B (100 000 to 400 000 pop.)...	37	22	18
Class C (10 000 to 100 000 pop.) ...	42	27	41
Class D (less than 10 000 pop.) ...	27	11	11

These figures indicate that (with the exception of Class C towns) the business noise measured in large cities was greater than that in smaller towns. This is believed to hold true despite a fairly large spread in individual measurements within a given class. The exception in the case of Class C towns is explained by the fact that a fairly large percentage of the measurements in this class were made in large factories.

* It will be noted that in the results given, the difference between the masking of the middle-frequency tone and the meter reading is relatively constant. It was found that for any considerable sub-group of the measurements, this difference was not far from 15 db. This figure, of course, would not in general hold for a single noise selected at random. There was a general tendency for the difference to be somewhat larger for larger values of noise.

Room noise in business locations was observed to be quite complex in frequency composition. The masking effect of the noise on the middle band was greater than that on the high and low bands. In order to give an approximate interpretation of this in terms of pressures in various frequency regions, account must be taken of the relative magnitudes of threshold pressures in the three warbler frequency bands, since the masking effects were obtained by subtracting threshold settings of the attenuator from the settings made in the presence of the noise. For the middle and upper bands, threshold pressures are about the same; hence, the lower values of masking for the high range indicate that components in this range are in general relatively weak. As previously determined,* threshold pressures at frequencies in the low band are several decibels higher than those in the other bands. Combining the values of masking for the low and middle bands with the corresponding threshold pressures, it is seen that the physical magnitudes of components in the low- and middle-frequency ranges are in general not far different. The above analysis is, of course, very rough, as the whole range from 250 to 5600 cycles is divided into only three bands.

Room Noise in Residence Locations.—Measurements were made in 96 residence locations.

Figs. 6 and 7 show distribution curves for these measurements. Compared with the corresponding measurements made in business locations it is apparent that the room noises encountered in residences were not only much smaller in magnitude but varied less in magnitude than business room noises. The average of the residence room noises is about 18 db less than the average of the business room noises, while the spread in residence room noise (using the 95 per cent. and 5 per cent. points on the curves as limits) is 20 db, against 40 db for business noise; the standard deviation of the residence measurements is 6 db, compared to 12 db for the business measurements. Unlike the curves for business noise, the curves for residence noise are very symmetrical, showing similar distributions above and below the average values.

As shown in Figs. 6 and 7, the median residence room noise would produce a reading of 7 db on the meter, and a masking of 12 db on the high-frequency warbler tone, 20 db on the middle-frequency tone, and 13 db on the low-frequency tone. The average was about the same as the median.

The average of the room noises measured in single-family houses was practically the same as the average of the noises measured in apartments.

Averages of the residence room noise measurements obtained in towns of various sizes are shown in the following table:—

Size of town.	Masking of middle-frequency tone.	Meter reading.	Number of measurements.
	db	db	
Class A (over 400 000 pop.) ...	20	7	33
Class B (100 000 to 400 000 pop.)...	20	8	14
Class C (10 000 to 100 000 pop.) ...	23	6	37
Class D (less than 10 000 pop.) ...	17	7	12

It will be observed from this table that the residence noises measured in large cities were no greater than those measured in smaller towns. A study of the data showed that 27 of the 33 measurements made in Class A towns were made in residences which would be classed as apartment houses. It is possible that the noise usually associated with big cities is confined chiefly to non-residential locations, and that apartments on side streets are no noisier than residences in smaller towns. It should be recalled, however, that the number of measurements in each class of town was very small. In any case the data tend

* H. Fletcher, "Useful Numerical Constants of Speech and Hearing," *Bell System Tech. Jl.*, July, 1925.

to show that the difference between residence noise in the large city and that in the smaller town probably is not extremely large. The measurements for Class A cities were made chiefly in Manhattan and Brooklyn, with a small number in Newark.

It was found, in a manner similar to that discussed above for business noise, that the average residence room noise was quite complex in frequency make-up, and apparently did not differ materially from the average business noise in the relative amplitudes of low and high frequencies.

Comparison of Room Noise in Winter and Summer.—Forty locations were visited, both in summer and in winter, and the data compared. It was found that both business and residence noises were somewhat greater in summer than in winter, the average difference being 4 or 5 db. The spread in values obtained under summer conditions was less than that found for the winter conditions. This was because the noises which showed the least magnitude, when measured in winter, were found to be higher under summer conditions, while the highest noises measured failed to show an appreciable change with season. These highest noises were largely caused by indoor machinery, and would not be appreciably modified by outside sources.

The average frequency composition of the noises measured under both summer and winter conditions seemed to remain about the same as far as could be determined.

Selection of Typical Room Noise and its Reproduction.

The data obtained have been used in determining the characteristics of a typical room noise to be recorded on a phonograph record and reproduced for use in laboratory tests.

Since the data revealed no difference between the average frequency composition of great and small noises, it has been possible to choose a single recorded noise and to vary merely the amplitude of the reproduced noise, keeping its frequency make-up constant.

The recording and reproduction of such a noise have presented problems, particularly from the point of view of naturalness. It has been found difficult to reproduce a noise by simple means in such a way as to give the illusion that the noise is real, not artificial. The requirements for reproducing a noise which will be typical in its effect on the intelligibility of speech transmitted over telephone circuit are, however, considerably less severe than those for obtaining naturalness. Three main factors seem to be involved in the problem. In the first place, room noises often contain high-frequency components, undoubtedly including some extremely high frequencies. These components, while they are generally of low energy content, seem to contribute substantially to the naturalness of the sounds. The effect of these components on the intelligibility of speech transmitted over a telephone circuit would, however, be much less than their contribution to the naturalness of the noise, since the transmitted speech is generally limited to a band of not more than 3000 cycles. The frequency band transmitted by the recording and reproducing system was nearly twice this amount, being limited both by the mechanical characteristics of the apparatus and by the unavoidable noise generated in this apparatus, the amount of this noise increasing as the band width increases. Second, room noises emanate from a considerable number of sources located in different positions, so that in order to reproduce them with complete fidelity each source must be reproduced separately in its own position. On account of binaural effects in hearing, the proper locating of sources seems to have a considerable effect on naturalness. The most practical method of securing an approximation to this effect in the reproduced noise is to dispose a number of loudspeakers in different places in the room, chosen by test so that false directional effects are avoided. Third, the effects of reverberation must be considered. A noise picked up in a highly reverberant room, and reproduced in another highly reverberant room, would have in it two sets of reverberations. The best method of taking care of this seems to be to make artificial adjustments in the reverberation in the two rooms. Finally, there is a residual effect due to the fact that a person experiencing an

actual noise is aided in his recognition of the noise by visual and other factors enabling him to refer it easily to its source; these are, of course, not present when the sound is reproduced.

List of Towns where Room Noise Survey Measurements were made.

Size of town.	Name of town.	Number of measurements.	
		Business.	Residential.
Class A (over 400 000 pop.) ...	Brooklyn, N.Y.	7	18
	Manhattan, N.Y. ...	32	13
	Newark, N.J.	0	2
	Total	39	33
Class B (100 000 to 400 000 pop.)	Jamaica, N.Y.	11	11
	Yonkers, N.Y.	7	3
	Total	18	14
Class C (10 000 to 100 000 pop.) ...	Bloomfield, N.J.	0	2
	East Orange, N.J. ...	7	9
	Flushing, N.Y.	0	5
	Harrison, N.J.	3	0
	Kearny, N.J.	6	0
	Maplewood, N.J. ...	6	10
	Milburn, N.J.	4	1
	Mt. Vernon, N.Y. ...	6	4
	New Rochelle, N.Y. ...	0	2
	Orange, N.J.	4	0
	Summit, N.J.	2	2
	West Orange, N.J. ...	3	2
	Total	41	37
Class D (less than 10 000 pop.) ...	Hollis, N.Y.	6	7
	Madison, N.J.	0	3
	Pelham, N.Y.	3	1
	Richmond Hill, N.Y. ...	2	1
	Total	11	12
	Grand Total ...	109	96

While a certain amount of work on room noise conditions in telephone locations had been previously carried out, this survey represents a considerable advance in knowledge of room noise magnitudes. It provides data for work on the effects of noise on telephone transmission, as well as furnishing certain information of wider interest. The methods of measurements employed, when further developed in the light of the experience gained in this work, should prove valuable in other room noise investigations.

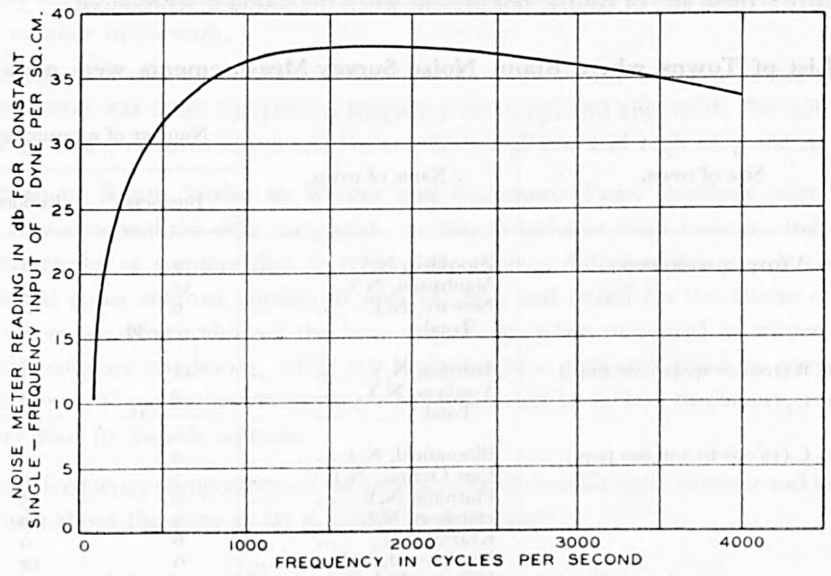


FIG. 1.—Response characteristic of room noise meter.

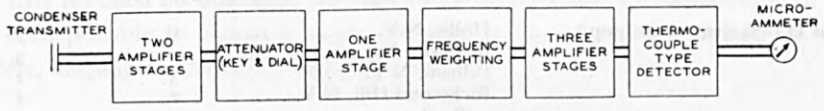


FIG. 2.—Schematic diagram of room noise meter.

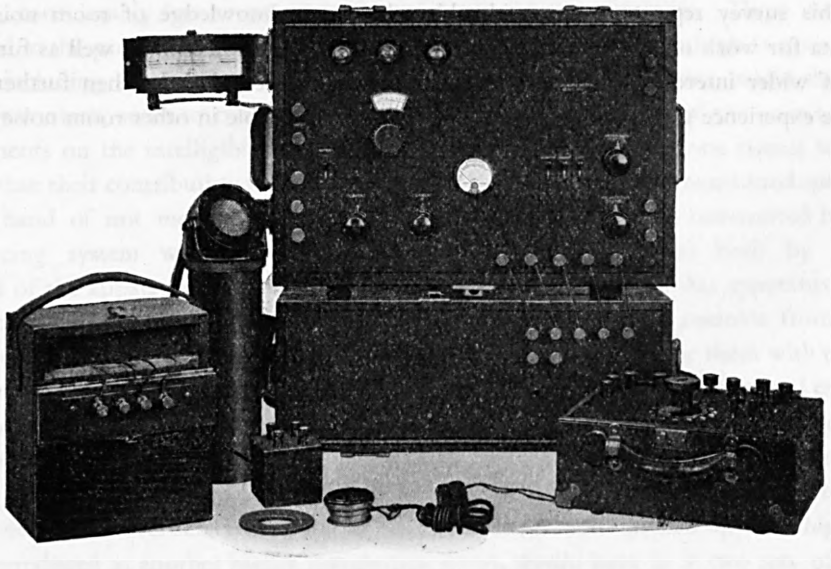


FIG. 3.—Room noise meter and auxiliary equipment.

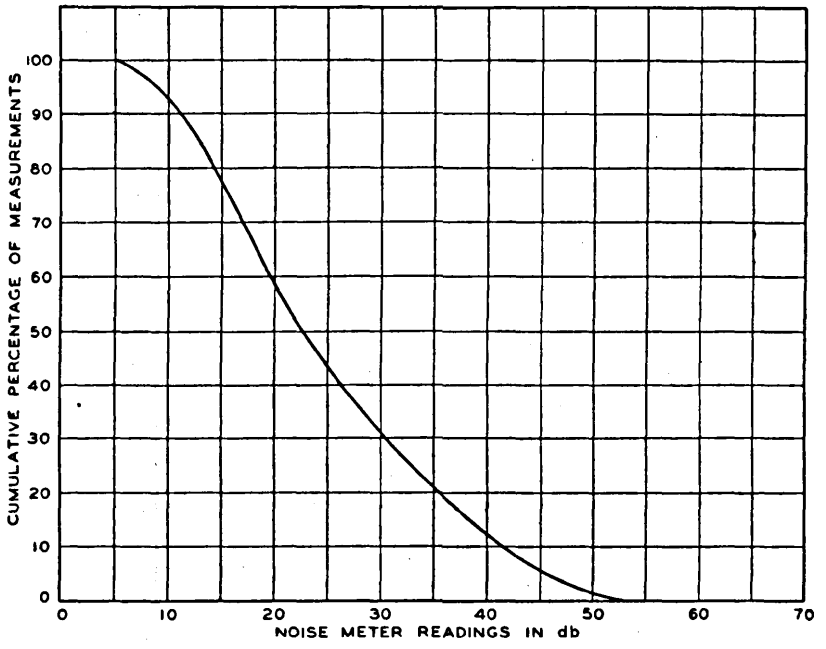


FIG. 4.—Results of noise meter measurements of noise in business locations.

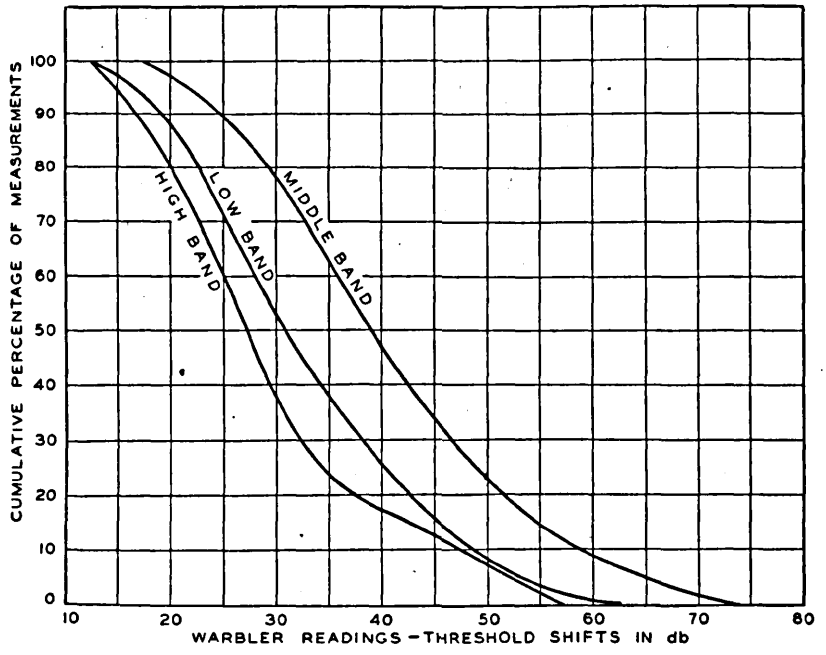


FIG. 5.—Results of measurements of noise in business locations by masking method.

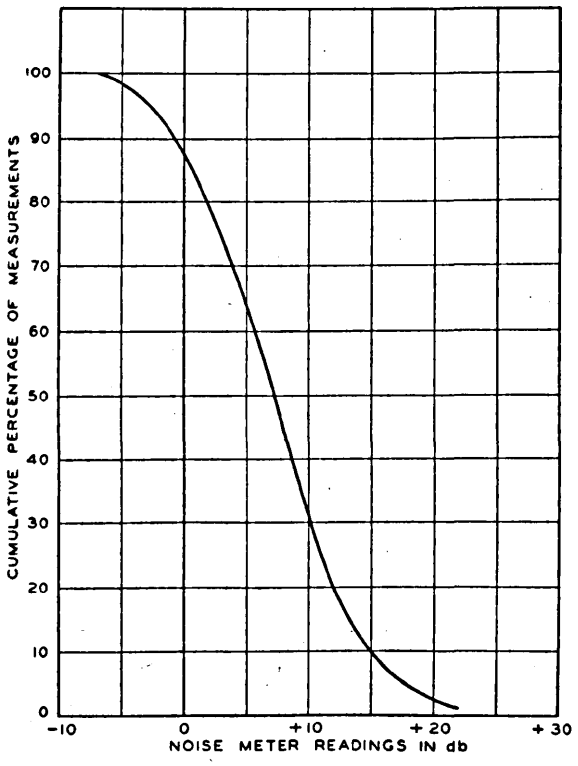


FIG. 6.—Results of noise meter measurements of noise in residence locations.

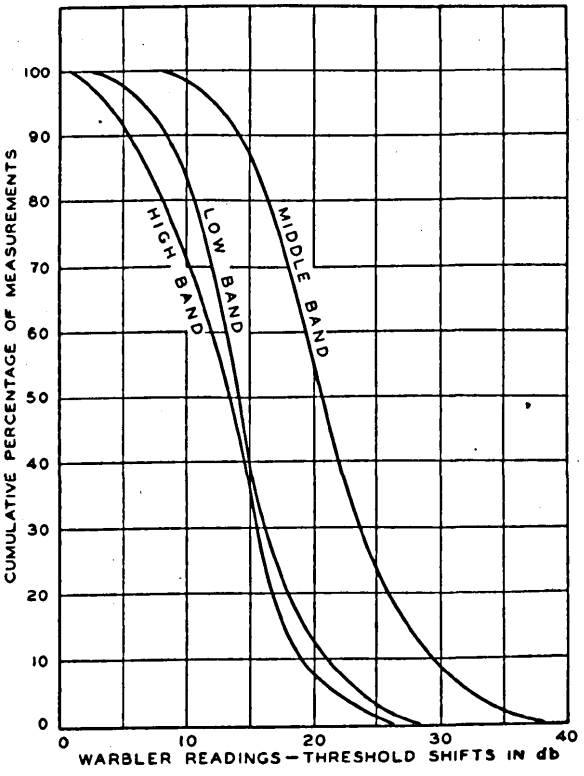


FIG. 7.—Results of measurements of noise in residence locations by masking method.

APPENDIX VIII.

NOISE.

Communication from the Heinrich Hertz Institute for Wave Research by Professor Dr. Karl Willy Wagner.

(Translated from: Sitzungsberichten der Preuss. Akad. D. Wissenschaften, Phys.-Math. Kl. 1931. IX.)

As people living in towns and cities are more and more crowded together, and in an increasing measure are making use of machinery, it has become evident that the influence of noise has assumed hitherto unknown proportions. Even in the past, complaints were made about troublesome noises: Schopenhauer, for example, on the subject of coachmen's whips. He also said that noise is the murderer of thought. Herbert Spencer used to say: one criterion of man's intellect is the horror he has of all useless noises. Numerous expressions of similar thoughts could be cited.* It has long been established that noise is not very pleasant and that, in fact, it interferes with intellectual work, but no one ever believed that noise was detrimental to health or reduced physical working capacity. Recent investigations, however, prove that such is the case; a brief account of this will be given here.

A strident, continuous noise has a deafening effect on the ear. This has been observed in the case of metalworkers employed in boiler factories and other noisy establishments. The same has been noted in other occupations, such as drivers, traffic police and street workers, who are continuously exposed to loud noises. Experiments on animals have shown that the basilar membrane, located in the inner ear and carrying the branches of the auditory nerve, may soon be mechanically deranged by heavy sound waves of a sustained character. Even if the loudness of the noise is not sufficient visibly to deform the organs of hearing, a deterioration of the latter manifests itself after a certain time, particularly when the intensity of the noise varies continually, as in the case of street noises and in several noisy establishments. It is well known that the normal ear is capable of responding to sounds, the intensity of which varies within extremely wide limits. The ratio between the most feeble sound (barely perceptible) and the most powerful sound, which is still below the limit of painful sensation, is as 1 to 10^{12}. The ear is only capable of detecting such variations because, like the eye, it can each time accommodate itself to the average level of the prevailing sound intensity. When big variations in intensity occur the faculty of adaptation gradually diminishes; the protective organs are fatigued, the protection vanishes and the poorly protected ear deteriorates. Long before a permanent lesion is formed the need for a continuous adaptation produces a general condition of fatigue in the organism.

A strident, continuous noise is harmful not only to the auditory organs, but also to the nervous system in general. Disturbed sleep has its bad effects. There is no doubt that the sleep of a normal and healthy person is disturbed when the nocturnal silence is broken, from time to time, by loud noises. It has been repeatedly stated that a person can get used to a continuous noise, the intensity of which remains constant. As a proof of this contention the story is told of the miller who slept soundly as long as the mill was working, but awoke when it stopped. The fact is that the miller's reaction to the noise proves the exact opposite. If the miller did sleep soundly and if during his sleep the noise had no influence at all on his nervous system, then he would not awake when the noise stopped. During the sleep the noise does, in effect, exercise a certain influence on the nervous system and maintains it in a certain state of tension. A measure of that tension is the intensity of the reaction which sets in when the noise stops, and it is this reaction which is sufficient to rouse a sleeping person.

The influence of noise on the various functions of the human body has lately been closely studied, especially in America. It has been found, by experiments, that the blood pressure rises in persons exposed to noise. Some individuals, subjected to these tests, had, for some reason or other, lost part

* *See* H. J. Spooner, *City Noise* (New York, 1930), p. 285. R. Berger, "Zur Geschichte der Lärmabwehrbewegung," published in *Die Schalltechnik*, 4th year (Berlin, 1931), p. 1.

of their cranium, and this enabled the experimenters to ascertain the pressure of the brain itself under the influence of noise. The soft part of the cranium was allowed to actuate a device which registered the vibrations of the brain. If, for example, a loud noise (the bursting of an inflated paper bag) was made behind a person under test, a marked increase was noted in the pressure of the brain, and the increased pressure was sustained, with irregular oscillations, for several minutes.* An increased activity of the heart has also been noted under the influence of noise.

Noise is also harmful to the functioning of the stomach. Smith and Laird,† in the Colgate Laboratory of Psychology at Hamilton, N.Y., made persons under test swallow a small rubber bulb, the hollow of which communicated through a tube with a pressure-registering device. The normal contractions of the stomach were thus observed, when the person tested was calm. When subjected to a noise of average intensity the contractions of the stomach became less marked, but more irregular. The effect of noise appears to be the same nature as that produced by fear or dread. Experiments on animals have given the same results. Reactions caused by noise are, moreover, similar to those of fear.

The above and other experiments having demonstrated the objective influence of noise on the functioning of numerous and vital organs in the human body, it is no longer a matter of surprise that a loud and, particularly, a sustained noise is detrimental to health. In further proof of this contention we possess a very delicate organ which never deceives us: continuous noise is disagreeable and a disagreeable sensation is nearly always harmful. It is unfortunate that a healthy person only notices harmful effects on his or her nervous system when the disorder has become worse, and difficult or impossible to cure. The last and most serious effect of continued noise is deafness. In noisy establishments 20 to 60 per cent. (in some cases 80 per cent.) of the workers are thus afflicted.

When noises diminish, attention slackens and causes an increased number of accidents in streets and factories, whilst the faculty of concentration in intellectual workers grows less. Not only is the capacity for intellectual work impaired, but the capacity for any kind of work is decreased in persons whose nervous systems are fatigued by noise. American institutes have demonstrated this condition by statistical data collected from various occupations. During these investigations, details of which will not be given here, the following interesting facts have been established. Noise imposes a greater physical tax on individuals engaged in manual labour: typists strike the keyboard harder than usual, paviors use their tools more vigorously, etc. Here, as in the case of intellectual work, it is noted that the effort exerted in counteracting the influence of noise imposes great strain on the nervous system, leading to considerable fatigue, over-excitement and, in the end, to neurasthenia.

Since it is recognised that noises are dangerous to health and capacity for work, efforts have been made in various countries to combat them. Several years ago the Zeitlerstiftung of the City of Berlin held a prize competition on the subject: "The war against street noises." Councillor Höltje, the prize-winner, treated the subject in detail from a technical and a legal standpoint. The Metal Workers' Christian Association published a Bulletin entitled: "Diseases in metal workers caused by noises," with a sub-title "To inform and help metal workers whose hearing is in danger or already impaired." This Bulletin describes the dangers due to noise and recommends a series of practical measures for the reduction of noise in industrial establishments. The "Note on the causes of deafness due to industrial noises and on possible remedies," published by the Hygiene Service of the Reich and by the German Society of Hygiene in Industrial Establishments, as well as the note, edited for the Physicians' Society of Berlin by Dr. Peyser, on the inconvenience caused by noises and the physiological ills which may follow, both have the same object in view.

In October, 1929, the Director of the Hygiene Service of the City of New York appointed a Noise Abatement Commission with the object of studying the causes and effects of noise in large cities and

* F. Kennedy, *City Noise*, p. 246.
† *Journal of the Accoust. Soc. of America*, Vol. 2, p. 94 (Menasha, Wis., 1930).

of preparing proposals to reduce it. The Commission, which was composed of physicists, technical experts, physicians, lawyers and officials, attacked the problem with great energy, and in the course of this year presented a Report of over 300 printed pages under the title *City Noises* which contains much valuable experimental data. The Commission worked in close collaboration with the Bell Telephone Laboratories, which placed at its disposal the necessary apparatus and personnel for acoustical research. Recently the German Engineers' Society (V.D.I.) appointed a Technical Committee on the reduction of noise (Fachausschuss für Lärmminderung), composed in an analogous manner to the Noise Abatement Commission. It has serveral Sub-Commissions, dealing with this question in its relation to Physics, Medicine, Technology, Legislation and Government, Education and Instruction, Finance.

In Austria a committee, formed under the auspices of the Austrian branch of the V.D.I., the Austrian Engineers' and Architects' Society and Association of Automobile Engineers, seeks to combat street noises.*

The first question which arises in noise research problems is the classification of different kinds of noise and particularly the relative importance to be accorded different sources of noise. In order to settle these points, questionnaires were sent out in New York containing a list of the most common sources of noise. Each recipient of the questionnaire was asked to indicate which one he had found most troublesome. Naturally such a classification, and especially the results of such an inquiry, depend upon the local conditions of a country. In order to form an idea of the relative importance of various kinds of noises in the large cities in Germany, the " Technical Committee on war against noises " of the V.D.I. proposes to address a questionnaire to teachers, physicians, engineers, and representatives of other professions on the following lines:—

A.—Noise due to Street Traffic.

Tramways (warning signals, brakes, car noise, grinding noises in curves, etc.).
Underground Railways.
Railways (locomotive whistles).
Automobiles.
Motor buses.
Motor cycles (horns, exhaust, brakes, etc.).
Motor trucks.
Tractors.
Horse-drawn vehicles.
Steam- and motor-boats.
Aeroplanes.
Construction work in the streets.

B.—Noises in Residential Districts.

Musical instruments (pianos, violins, etc.).
Loudspeakers, gramophones.
Cleaning tools (vacuum cleaners, blowers).
Water pipes.
Elevators.
Milk deliveries (signals, handling of cans).
Garbage removal.
Entertainments (dance music, etc.).
Factories and workshops.
Noises made by the residents (indicate what kind).

* L. Richter, Bekämfung des Strassenlärms durch Verwaltung, Technik u. Wissenschaft, *Sparwirtschaft*, p. 569 (Vienna 1930).

It was to be expected that the various sources of noise would be very differently evaluated by the individuals asked. The inquiry should, however, yield an average statistical value. As the questionnaire indicates, and the above classification impressively confirms, the dwellers in the large cities are treated to an infernal symphony of noises.

The problem to be dealt with now is the measurement of the intensity of the noise. Since a noise is the resultant of component noises, that is to say, a mixture of sounds, the components of which have no harmonic interrelation, nor form a continuous sound spectrum, the question arises how to define intensity of noise. If a measurement—that is, a comparison with reference noise, is to give a criterion on the effect of noise on the ear, it is necessary to resort to an audiometric comparison.* As a reference noise a pure sound with a frequency of 1000 p : s has been arbitrarily chosen. This intensity of noise is expressed either as the acoustic intensity N (in the case of a single plane), or as the average density of the acoustic energy W (in the case of radiation in a closed space). Because of the great differences in noise levels, the logarithm of the ratio of the noise intensities compared is used. Briggs logarithm, multiplied by 10† is by definition the relative logarithmic value of the noise intensities compared L :

$$L = 10 \log N_1/N_2 \text{ or } L = 10 \log W_1/W_2$$

As zero point on the scale of noise intensities thus defined, a noise has been chosen, the intensity of which corresponds to the threshold of hearing, that is to say, an acoustic intensity :—

$$N = 2.7 \times 10^{-10} \text{ microwatt/cm}^2$$

or an acoustic pressure $p = 3.3 \times 10^{-4}$ dyne/cm², or an average acoustic energy $W = 0.8 \times 10^{-13}$ erg/cm³.

The relative logarithmic values of noise intensity are expressed in " phones " (decibels).

Several methods have been proposed for the technique to be used in noise measurements, that is to say, the audiometric comparison of a given noise with an adjustable reference sound.

In the noise measuring set of Barkhausen‡ the noise to be measured exerts its pressure on one ear and the reference sound, through a telephone receiver on the other ear. The reference sound is varied until equality is obtained in the subjective sound intensities. In view of the different quality of the two sounds compared it is difficult to estimate, subjectively, the equality on their intensities. The measurement requires considerable skill.

The audiometer of the Western Electric Co.§ uses a telephone receiver, fitted with a special cap with openings at the side, and placed at a fixed distance from the ear. The noise enters the ear through these openings, whilst the same ear also observes the reference sound emitted by the telephone. The reference sound has a frequency continuously varying between two fixed limits.‖

The sound intensity is adjusted until the reference sound is masked by the noise. The increase, due to the noise, in the value of the acoustic intensity, corresponding to the threshold of hearing, is thus considered as a measure of the noise intensity. If measurements are made with artificial sounds of various average pitches, a certain indication is obtained of the width of the sound spectrum corresponding to the noise observed, assuming that the masking effect is determined chiefly by noise components of the same pitch.

Audiometer measurements are also difficult to make, and there is a need for some objective method of measuring noise intensities. For this purpose a device should be used which, like the ear, should be

* The considerations which follow are in line with the proposition of the Standards' Commission relative to the definition of the intensity of noise. It is closely akin to the proposition already adopted in America.

† The multiplier 10 is used in order that the unit of sound intensity may be of a magnitude comparable with still perceptible differences in intensity, so that the numerical value of L may be given without decimals.

‡ H. Barkhausen, Ein neuer Schallmesser für die Praxis, Zeitschr. *F. Techn. Phys.*, Vol. 7, 1926, p. 599.

§ H. Fletcher, *Speech and Hearing*, p. 104, London 1928.

‖ R. H. Galt, *Journ. Acoust. Soc. Am.*, Vol. 1, p. 147, 1929.

able to discriminate between sounds of different pitches (see the curve of the sensitivity of the ear, Fig. 1 below).

This might be realised by directing the noise towards a microphone (of the condenser type) which is equally sensitive at all frequencies and inserting between this microphone and the registering device a quadripole, the attenuation/frequency characteristic of which corresponds to the sensitivity curve of the ear. A device of this kind is actually being developed in several places.

Since the various methods of noise measurement are based on different principles, it is necessary to establish some kind of a relation between the results obtained by these methods. This can be done

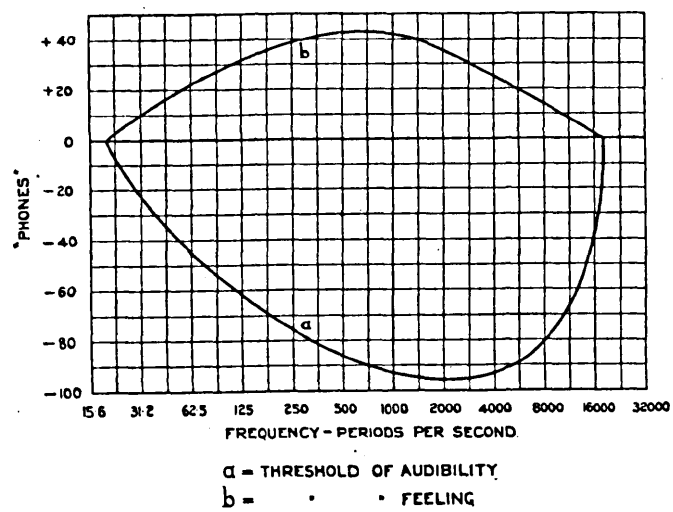


FIG. 1.

by measuring a sound of reproducible intensity with the different methods. Systematic comparisons of this kind have, however, not yet been made.

Below are given the values of noise intensities measured in New York by means of an audiometer. These values are the increases (above the threshold of hearing, corresponding to a reference sound) due to the masking effect of the noise.

Noise Measured.	*Phones.*
Average noise in New York apartments	20-45
Average noise in offices, clubs, etc.	30-70
Street noise	45-80
Average noise in particularly busy streets	67-75
Barking of a dog in the street (distance 4 m)	50-75
Thunder (average)	60-70
Church bells (distance 400 m)	50-60
Loudspeaker used for advertising	80
Pneumatic drill (street paving)	88
Steamship siren in the harbour	93
Underground express train passing a station	94
Riveting on buildings under construction	97

Fig. 2* gives the variations in the intensity of the noise at a street crossing during average traffic conditions for 24 hours. It is interesting to note that, even during the night, the noise remains at the same level as during the morning or afternoon hours when the traffic is heaviest.

In taking measures to abate noises, it is well to distinguish between those produced in the streets, those in factories, and those in residential parts. Generally speaking, much of the noise can be reduced in a simple and inexpensive manner, once the importance of noise abatement is understood and some good-will is invoked. Unfortunately, one cannot always count on good-will, and the ruling authorities should therefore take the necessary measures, as has already partly been done.

Poorly maintained trucks with defective tyres or badly loaded or over-loaded trucks contribute considerable amounts to street noises. All measures which aim to reduce noise help to maintain the roads, whilst, inversely, bad roads increase traffic noises. Motor-cycles are particularly objectionable sources of noise, although a suitable exhaust, and especially proper handling of the machine, reduce the noise.

Reduction of noises due to tramways is chiefly a technical problem which is now being studied, but which presents certain difficulties to the constructional engineers.

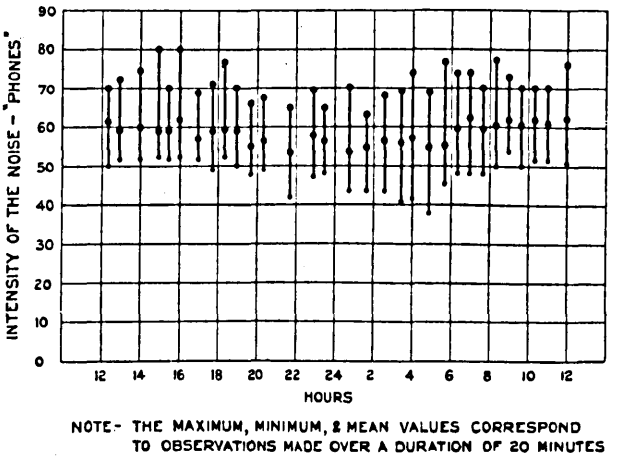


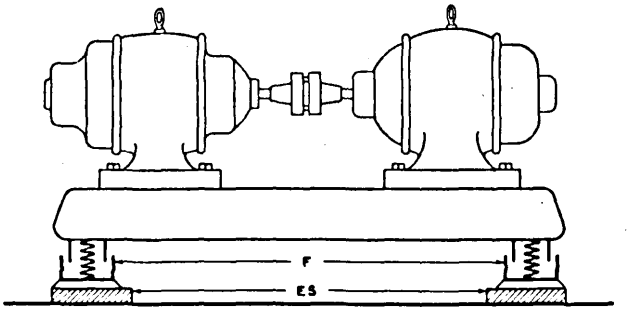
FIG. 2.

The Noise Abatement Commission in New York has made some notable researches in the field of automobile horns. These researches show that the purpose of the horn (effective warning signal in emergencies) can be reconciled to the exigencies of noise reduction. A majority of people, subjected to tests, declared that sufficiently powerful horns, which however give the least disagreeable sensation, are those which emit sounds, the high frequency components of which are few in number and are all harmonics of the fundamental note. The Commission insists that the fundamental frequency of the horns shall be 200-300 p : s, and that the higher frequency components shall only consist of harmonics, the frequency of which must not exceed 4 000 p : s, the power being distributed almost uniformly between all of the components. Such horns give a musical note which can be heard in street noises, if its intensity is approximately equal to the average intensity of the noises. A value of 90 phones has been adopted for the sound intensity of a horn at a distance of 7 metres from the vehicle. The average noise intensity in a street is 78 phones, at most. Therefore, according to the law of a decrease in sound intensity in proportion to the square of the distance, the horn will still be heard in the greatest street noise at 28 metres (the attenuation in the sound intensity will be $10 \log 4^2 = 12$ phones), which may be considered sufficient.

* Reproduced from *City Noise*, p. 134.

In order to reduce the noise in industrial establishments, noisy machines should be placed on elastic supports, so as to prevent the vibrations being conveyed to tables, floors, walls and other objects with large surfaces, from which the vibrations are readily transmitted and radiated in the air.

Experiments, made at the Heinrich Hertz Institute for Wave Research, show that it is often necessary to isolate a machine by a double elastic support (Fig. 3), as it is difficult to design a single suspension which is equally efficient at high and low frequencies. Metal springs, especially flanged springs, attenuate very effectively slow vibrations, but transmit the high frequencies, at which they oscillate in a quasi-stationary manner. Supports of rubber and similar material absorb high frequencies very efficiently, but are of no value at low frequencies. In practice the two types of suspension are therefore used in series.



F - METALLIC SPRINGS.
ES - ELASTIC INTERMEDIATE LAYER.

FIG. 3.

In rooms with hard floors and smooth, bare walls, noise becomes of particularly great importance. This is easily understood since between the density W of the sound energy at one point in the room and the total power N of the sound source, the following relation exists:—

$$W = 4N/aA$$

where a is the speed of propagation of sound and A the absorption coefficient of the wall. Thus, if W reaches such values that the noise becomes unbearable, the absorption coefficient A must be increased by covering the floor and the walls with absorbent material.

Noise conditions in residential dwellings will not be dealt with here since these are largely a matter of deference between neighbours in the houses in the large cities. We will, however, touch briefly on the problem of sound penetration through walls. A wall may, in principle, transmit sound in two ways: (1) by allowing the sound to penetrate as a longitudinal vibration and (2) by being set into vibration under the influence of the acoustic pressure in one room and transmitting to an adjacent room, as would a large diaphragm. The question, hitherto unanswered, how these two phenomena contribute to the penetration of sound through a wall, has been solved through the tests made by Mr. Erwin Meyer of the Hertz Institute. Meyer found that the diaphragm effect of the wall practically determines its permeability to sound.*

It is therefore possible to calculate the acoustic isolation of a wall from its mass and elastic properties. In the majority of cases the calculation is simplified by the fact that the natural frequency of the wall is below, or at least on the limit of, the voice frequency band. In considering the mechanical impedance of

* Erwin Meyer: *Grundlegende Messungen zur Schallisolation von Einfachwänden*, p. 166.

the wall, one may therefore neglect the elasticity component in reference to the component of inertia. Consequently, the external force K, exerted by the acoustic pressure on the wall may be expressed as:—

$$K = m \frac{ds}{dt} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where s is the velocity of the wall at its maximum deviation, m is the mass in vibration as a diaphragm per square centimetre of surface.

We know that:—

$$m = 0.17 \times d \times \rho_\omega \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

d = the thickness of the wall.

$\rho\omega$ = its density.

If p denotes the effective value of the acoustic pressure, being exerted on the wall, we have:—

$$K = \sqrt{2}\, p \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

For sinusoidal sound waves of ω radians we deduce from equations (1) and (3):—

$$s = K/m\,\omega = p\,\sqrt{2}/\,0.17 \times d \times \rho_\omega \times \omega \quad \ldots \quad \ldots \quad (4)$$

The acoustic power received by the wall surface (surface F) is:—

$$N_1 = Fp^2/4a\rho \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

a being the velocity of sound and ρ = density of air.

The power radiated in the adjacent room by the wall acting as a diaphragm is:—

$$N_2 = S\, s^2/2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

The resistance to radiation S is:—

$$S = k\, a\, \rho \quad F\, h \quad R/\lambda \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

λ = the wave length of sound.

R = the radius of a circular diaphragm equivalent to the wall.

For ordinary values of the ratio R/λ (excepting at very low frequencies) $h = 1$.* The factor k takes into account the fact that all parts of the wall do not have equal oscillation amplitude; this factor depends on the form of the oscillation and for our purpose we may consider it equal to 0.5.

Bearing in mind equation (4), we obtain:—

$$N_2 = k\, a\, \rho \quad F\, s^2/2 = k\, a\, \rho \quad F p^2/0.029\, d^2\, \rho_w^2\, \omega^2 \quad \ldots \quad (8)$$

The acoustic isolation afforded by the wall, expressed in phones as a ratio of N_1 to N_2, is:—

$$w = 10 \log \; N_1/N_2 = 10 \log \; 7.2 \;\; 10^{-3}\, d^2\, \rho_w^2\, \omega^2/k\, a^2\, \rho^2 \quad (9)$$

For a plastered, quarter-brick wall, the acoustic isolation, obtained from measurements of sound intensity, is:—

$$w = 50 \text{ phones} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10A)$$

for a sound with frequency 1600 p : s.

Inserting in formula (9) the values: $d = 9$ cm. (wall thickness) $\rho_w = 1.7\, g/cm^3$, $\omega = 10000$, $a\rho = 41.5$ at room temperature, we get:—

$$w = 53 \text{ phones} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10B)$$

Allowing for the assumptions made in arriving at formula (9) the agreement between the theoretical and tested values is satisfactory.

---

* H. Backhaus, *Handbuch der Physik*, Vol. 8, p. 115.

It is of interest to note that the amplitude of the vibrations of the wall is very small. Denoting it by A, we obtain from equations (1) to (3) for sinusoidal vibrations :—

$$A = K/m\,\omega^2 = p\sqrt{2}/0.17.\,d\;\rho_w\;\omega^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

For a sound, corresponding to an effective pressure $p = 10$ dynes/cm^2 ($\omega = 10000$), the formula (11) gives the amplitude of the vibration of the brick wall considered :—

$$A = 5.5 \quad 10^{-8} \quad \text{cm.}$$

The amplitude, measured by E. Meyer, was :—

$$A = 6.4 \quad 10^{-8} \quad \text{cm.}$$

Again, the agreement is as good as might be expected.

Formula (9) shows that the acoustic isolation afforded by a wall increases with its weight and with the pitch of the sound. The formula holds good only for a single wall. Further research is necessary to determine the acoustic absorption of double or multiple walls.

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